HEAT TRANSFER THROUGH CAVITY WALLS

A thesis presented for the degree of
Doctor of Philosophy in Chemical Engineering
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by

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"In this work, when it shall be found that much is omitted, let it not be forgotten that much likewise is performed ...."

SAMUEL JOHNSON, A.M.

'Dictionary of the English Language'

Vol. I, page 5, 1755, London

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This work is dedicated to my mother,

Mrs Lyeneno Lishomwa,

and my madame, Anne Umbers

CONTENTS

Appendices

ABSTRACT

The aims of this study were:

(a) to develop a numerical method and

(b) to develop an experimental method for the prediction of heat transfer in a cavity in which radiative transfer, gaseous and solid conduction are occurring.

In the experiments, the thermal conductivities of various materials (perspex, durotherm and particle board) were measured to within 1%. The rates of heat transfer across the materials (specimens) were measured for different values of:

(a) temperature difference across the specimens - dT varied between $1^{o}C$ and $51^{o}C$

(b) material (specimen) thickness - 5.6mm, 9.7mm, 11mm, 12mm and 19mm thick specimens were used

(c) cavity size - 30.5mm, 34.925mm, 35.5mm and 40.5mm diameter holes were used

The results are presented in graphical and tabular forms (rate of heat transfer versus temperature drop). As expected, the rates of total heat transfer decreased with increases in the hole size and specimen thickness. The effects of radiation transfer were assessed by blocking the holes with aluminium foil. The results showed that radiation transfer was small (about 5% of the total heat transferred).

For four different values of the emissivity of aluminium (0.04, 0.11, 0.2 and 0.5), the method computed:

(a) the heat transferred by solid conduction - this was

found to be constant for all values of emissivity

(b) the heat transferred by gaseous (air) conduction - this too did not vary with emissivity

(c) the radiation transferred between the surfaces in the hole - this varied significantly with emissivity

(d) the total heat transferred

The results obtained from the numerical simulations are presented in graphical and tabular forms. Depending on the emissivity value used, the percentage of radiation transfer varied between 2 and 15% of the total heat transferred. Correspondingly, the air conduction varied between 9 and 17% of the total heat transferred. Hence solid conduction was the dominant mode of heat transfer (68 to 89% of the total heat transferred).

When using the material durotherm, the experimental and the theoretical results were in agreement within the limits of experimental error. When using perspex, only half of the results were within the limits of experimental error. The discrepancies for the perspex runs varied between 2 and 26%. Reasons are advanced to explain these discrepancies.

CHAPTER 1

INTRODUCTION

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INTRODUCTION

Heat is defined as energy transferred by virtue of a temperature difference or gradient and is vectorial in the sense that it flows from regions of higher temperature to regions of lower temperature. The basic modes of heat transfer are conduction and radiation.

Conduction is a process by which heat flows from a region of higher temperature to a region of lower temperature within a medium (solid, liquid or gaseous) or between different mediums in direct physical contact. The conduction process takes place at the molecular level and involves the transfer of energy from the more energetic molecules to those with a lower energy level. Irrespective of the exact mechanism, which is by no means fully understood, the observable effect of heat conduction is an equalization of temperature. Conduction is the only mechanism by which heat can flow in opaque solids. Conduction is also important in fluids, but in non-solid mediums it is usually combined with convection, and in some cases with radiation also.

Radiation, or more correctly thermal radiation, is electromagnetic radiation emitted by a body by virtue of its temperature. Thermal radiation is of the same nature as visible light, x-rays and radiowaves, the difference between them being in their wavelengths. The wavelength range normally associated with thermal radiation falls approximately between 0.1 and 100 microns. All solids and liquids, as well as some gases, emit thermal radiation. The intensity of the emissions depends on the temperature and nature of the surface.

Convection, sometimes identified as a separate mode of heat transfer, relates to the transfer of heat from a bounding surface to a fluid in motion, or to the heat transfer across a flow plane within the interior of the flowing fluid. If the fluid motion is induced by a pump, blower, fan, or some similar device, the process is called forced convection. If the fluid motion occurs as a result of the density differences produced by the heat transfer itself, the process is called free or natural convection. Detailed inspection of the heat transfer process in these cases reveals that the basic heat transfer mechanisms are conduction and radiation, both of which are generally influenced by the fluid motion. Convection is most important as the mechanism of energy transfer between a solid surface and a liquid or a gas.

In the solution of heat transfer problems, it is necessary not only to recognize the modes of heat transfer which play a role, but also to determine whether a process is steady or unsteady.

1.1 MOTIVATION AND GENERAL OBJECTIVES

In contrast to conductive and convective heat transfer problems, radiative transfer problems are described, not by differential equations, but by integral equations. Analytical solution of these integral equations, even for the simplest of practical problems, is generally quite difficult and recourse is usually made to numerical methods. When radiant heat transfer and other modes of energy transfer act simultaneously, or interact, the governing equations are non-linear integro-differential equations. Solution of the latter becomes inordinately complex and computer methods are the rule.

Notwithstanding the above, the availability of high-speed digital computers permits great latitude in so far as the level of approach taken in the solution of such problems. Indeed, at one extreme, many complex interaction problems are amenable to solution from first principles with present-day computational capabilities. Such fundamental approaches, however, raise the question as to when this degree of mathematical sophistication is warranted in the solution of problems for engineering purposes. In considering the limited knowledge available about radiation interaction, it appears desirable to employ detailed methods to initially solve simple problems and use the results to delineate the basic physical phenomena. Ideally, the end-product of this approach should be the development of simplified calculational procedures which would be of greater engineering utility in more complex situations.

The primary objective of this study was to develop and demonstrate the validity of a numerical method for the prediction of heat transfer in a cavity in which radiative transfer, gaseous and solid conduction are significant. The study concentrated on finite difference methods for the solution of the primitive equations of motion and energy; an experimental study was also made to verify the analysis.

This work is part of a continuing research effort directed towards an improved general understanding of the physics of processes in which radiative heat transfer interacts with other modes of energy transfer, and the development of improved associated computational procedures. While techniques (4,7,14,137) are currently available for the solution of simple situations of conduction-radiation interaction problems in two dimensions in an absorbing-emitting media, this work represents a first attempt with a practical geometrical set-up and in three dimensions. Convection-radiation interactions are well summarised by Noble J.J. (3).

As shall become apparent, a survey of available literature revealed that considerable effort has been expended in predicting and measuring heat transfer characteristics in enclosures and cavities; however, a thorough, and simplified method dealing with conduction-radiation interaction was not found in any of this material.

1.2 RESEARCH UNDERTAKEN

The work undertaken in this thesis can be divided into three parts:

(1) the design, construction and operation of the experimental equipment (Chapter 2)

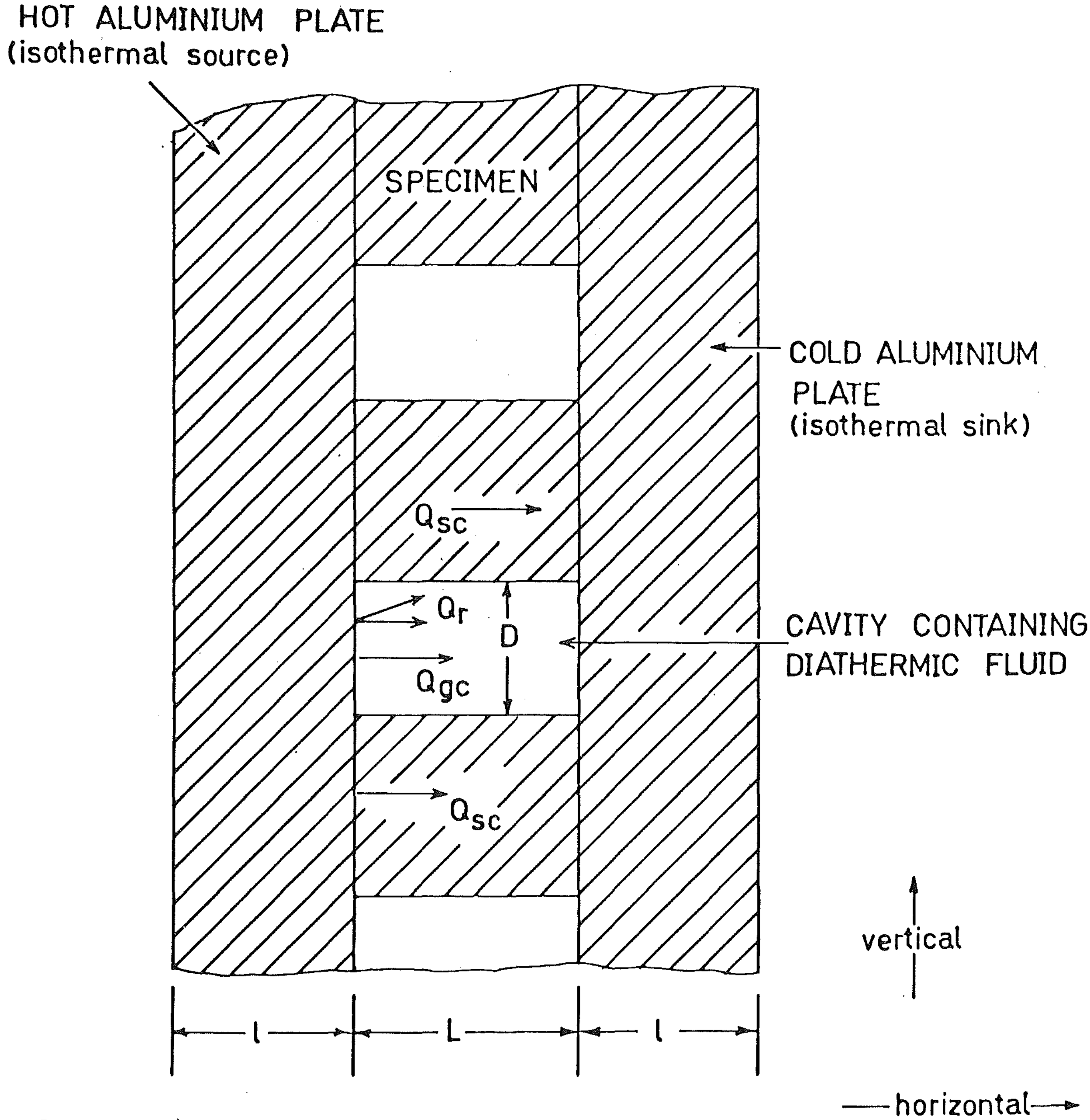
(2) the development of the numerical simulation of the experimental set-up (Chapter 1)

(3) the comparison and verification of the experimental and theoretical simulations (Chapters 4 and 5)

1.3 PROBLEM STATEMENT

The problem considered is that of the heat transfer mechanisms which occur when a diathermal fluid is contained in a cavity, the walls of which are conducting. Specifically, attention will be given to a cylindrical cavity.

As shown in Figure 1-1, one end of the cylindrical enclosure is an isothermal sink, and the other is an isothermal



Q_{sc} - heat transfer by solid conduction

Q_{gc} - heat transfer by gas conduction

Q_r - heat transfer by radiation

FIGURE 1-1 SKETCH OF A CAVITY SHOWING ITS MAIN COMPONENTS source zone. Energy is transported from the source to the sink by fluid conduction, solid conduction, and radiative transfer between the walls of the enclosure. Convective transfer is neglected by doing all the work (theoretical and experimental) below the critical Rayleigh number (1,8,11,12). The problem is hereafter referred to as 'the cavity problem'.

As can be shown from dimensional analysis (1,9,10,14,15, 3,17), the cavity problem is a function of the following dimensionless numbers:

1. Aspect ratio of enclosure
2. Grashof number
3. Prandtl number
4. Orientation of gravity
5. Radiation-conduction parameter (or Stark number)
6. Optical thickness (based on a system dimension)
7. Emissivity of the surface
8. Ratio of the absolute source and sink temperatures

It is clear that a complete description of the problem will require considerable theoretical and experimental effort and time. This is partially the reason for the emphasis in this thesis on the numerical and practical aspects of the problem.

The cavity problem is a good test problem for several reasons. First, it is one of the simplest enclosed interaction problems that could be simulated experimentally and theoretically. Second, problems closely associated with the cavity problem have received some attention in the literature. Both theoretical solutions and experimental data are available with which the present work can be compared. Third, there are many practical applications which can be closely associated with the cavity problem.

1.4 PRACTICAL APPLICATIONS

The mathematical significance of the cavity problem is considered to be at least as important as its practical value and the focus of attention in this thesis is so divided. The cavity problem is of importance in a number of practical situations.

One of the applications is in the thermal insulation field. Radiation transfer and solid conduction are important in determining the effectiveness of thermal insulation (6,13) in cryogenic storage equipment and high temperature thermal protection systems. For example, that used in spacecraft installations - Skylab I for instance. In most cryogenic and space applications, cavities are used to reduce conduction losses and by using low emissivity surfaces in evacuated conditions, reductions in radiation transfer also result. Cavity walled structures are also used to provide high strength -to-weight ratios especially in aircraft. Other areas of insulation engineering where the cavity problem is of significance include building insulation, double-glazing of windows, and the cavities surrounding the core of a nuclear reactor.

A second application is concerned with furnace design. In the steel industry for example, the trend is away from batch production toward large-scale, automated, continuous processes, and therefore the degree of control over furnace conditions must become necessarily finer. As most furnaces are of cavity wall construction for thermal and economic reasons, using the techniques described in this work, it is possible to get better design methods and operating characteristics for furnaces.

A third area of application that has arisen more recently is in the design of solar energy collectors. In the design of these collectors, particularly the flat plate type, the amounts of radiation, convection and conduction heat transferred from the heated plate must be known in order to compute the efficiency of collection (16,18).

1.5 OUTLINE OF PRIOR WORK

1.5.1 BACKGROUND AND THEORY

Heat transfer processes in enclosures have received increased attention in recent years. Most attention has been to convection transfer in enclosures (natural and forced) (8,18). Conduction and radiation transfers have received very little attention. This section of the work reviews the experimental, numerical and analytical studies on vertical, inclined and horizontal cavities.

1.5.1.1 Fundamentals of Heat Transfer

(1) Definitions:

(a) Thermal Conductivity - is defined as the property of a homogeneous body measured by the ratio of steady-state heat flux (time rate of heat flow per unit area) to the temperature gradient (temperature difference per unit length of heat-flow path) in the direction perpendicular to the area. A material can be considered homogeneous when the value of thermal conductivity is unaffected by variations in specimen thickness or area over a small temperature range.

To be meaningful, thermal conductivity must be identified with respect to the mean temperature. For a material that is not isotropic, thermal conductivity varies not only with temperature, but also with the direction and orientation of heat flow. Thermal conductivity is usually measured with a material exposed to a definite temperature difference. If the heat flux consists of a convective and radiative as well as a conductive contribution, the thermal conductivity calculated or measured is termed 'effective' or 'apparent'.

(b) Emittance - is the ratio of emission of radiant energy by an opaque material to the emission of a perfect emitter, or blackbody, at the same temperature and under the same geometric and wavelength conditions. Emittance, a practical measure of a material's radiant emission, is distinct from emissivity, a more nearly ideal property obtained by measuring a material whose surface has been carefully prepared to be optically flat.

(2) Basic laws of heat transfer:

The basic physical laws and relations which govern the various mechanisms of heat flow are:

(a) Conduction - the basic relation for heat transfer by conduction was proposed by the French scientist, J.B.J. Fourier, in 1822. It states that q_c, the rate of heat flow by conduction in a material, is equal to the product of the following three quantities:

(i) K, the thermal conductivity of the material

(ii) A, the area of the section through which heat flows by conduction, to be measured perpendicularly to the direction of heat flow

(iii) dT/dx, the temperature gradient at the section

Accordingly, the elementary equation for one-dimensional conduction in the steady-state is written:

$$q_c = -KA\frac{dT}{dx} \tag{1-1}$$

(b) Thermal Radiation - the basic equation for total thermal radiation from the ideal radiator (the 'blackbody') was discovered empirically by Stefan in 1879 and was derived theoretically by Boltzmann in 1884:

$$q_r = \sigma A T^4 \tag{1-2}$$

where q_r is the rate radiant energy emission, W

A is the surface area of the emitting surface, M^2

T is the absolute surface temperature, ^OK

σ is the Stefan-Boltzmann constant, $W/M^2/^OK^4$

Real bodies do not meet the specifications of an ideal radiator but emit radiation at a lower rate than blackbodies. If they emit, at a temperature equal to that of a blackbody, a constant fraction of blackbody emission at each wavelength, they are called gray bodies. The rate of emission of radiant energy of a gray body at a temperature T_1 is:

$$q_r = \sigma A \varepsilon T_1{}^4 \tag{1-3}$$

where ε is the emittance of the gray surface.

(c) Convection - in 1701, Newton defined the heat transfer rate q_{co} from a surface of a solid to a fluid by the equation:

$$q_{co} = h_{co}A(T_s - T_f) \qquad (1\text{-}4)$$

where q_{co} is the rate of heat transfer by convection, W

A is the heat transfer area, M^2

T_s is the surface temperature, ^{o}C

T_f is the fluid temperature at some specified location (usually far away from the surface), ^{o}C

h_{co} is the surface coefficient of heat transfer (or the convective heat transfer coefficient), $W/M^{2\,o}C$

1.5.2 REVIEW OF EXPERIMENTAL METHODS

It is mentioned at the outset that little work has been found which is related to measuring heat transfer rates in enclosures with conduction and radiation as the predominant modes. As such, the discussion of prior investigations pertinent to this study is of a general nature.

1.5.2.1 Heat Transfer Across Vertical and Horizontal Fluid Layers

The first systematic experimental investigation - directed at obtaining generalised relationships for the transfer of heat through enclosed, plane air layers - was made by Mull and Reiher (19) in 1930. They measured the steady-state heat transfer rate by natural convection across air layers. Most of their experiments were conducted for horizontal and vertical cavities. Their results were presented in the form of a Nusselt-Grashof number correlation.

The results of Mull and Reiher were represented in a simplified form by Jakob (20,21). It was suggested that there are essentially three regimes of heat transfer occurring within vertical air layers. At low values of Gr only gaseous conduction occurs and Nu equals unity; the convective flow region can then be divided into laminar and turbulent regimes. The results were again presented in empirical relationships.

In 1951, Peck et al (22), performed a series of experiments on vertical, enclosed gas layers in which the environmental pressure was varied. The radiative, Qr, and solid conductive, Qsc, components of the total heat flux passing across the cavities were obtained by evacuating the test cell to a pressure of approximately 2×10^{-5} torr. At such vacua, the gaseous conductive and convective heat transfers are completely eliminated. Their experiments could not distinguish Qr from Qsc. They however, obtained empirical correlations for air, at environmental pressures in the range 1 - 100 torr. Kent (23) used a similar technique to obtain correlations of Nusselt and Rayleigh numbers for horizontal fluid layers in 1972.

De Graaf and Van der Held (9) examined the transfer of heat across enclosed air layers in horizontal, vertical and inclined positions. Attempts were made to determine the convective flow patterns occurring within air layers by means of both a modified shadow-graph technique and smoke methods. It was concluded from these tests that convection did not occur in vertical air layers provided $Gr < 2.78 \times 10^3$, and that if $Gr > 5.55 \times 10^4$ laminar flow existed. When this Grashof number was exceeded, a gradual transition to turbulent flow ensued. The radiation contribution of the total flux transferred across a layer was incorrectly assumed to be the heat transferred through a horizontal air layer when the hot wall was placed uppermost. The experimental correlations given were in good numerical agreement with those of Jakob.

The thermal insulating values of enclosed air spaces, with particular reference to buildings, have been studied by Robinson and Powlitch (24). Steady-state heat transfer measurements were obtained with enclosing surfaces of differing emissivities at five different inclinations of each cavity and for various directions of heat flow. Values of the combined conduction-convection heat transfer coefficients were plotted against the air layer thickness, with temperature difference as an experimental parameter. They concluded that for a given orientation and temperature difference there is an optimum thickness of air layer at which the thermal resistance of the air space has a maximum value, though at large air thickness values, greater resistances may be encountered.

The first detailed, phenomenological study of the heat transfer processes occurring within vertically-enclosed air layers was presented by Eckert and Carlson (25), who used a Mach-Zehnder interferometer to determine the temperature distribution within the air layers. Three regimes of flow were distinguished in the range $2.92 \times 10^2 < Gr < 1.94 \times 10^5$. The conduction regime was defined to exist when a linear temperature gradient was established in the central portion of the cavity. The conditions under which a core of uniform temperature was established across the cavity, with thermal boundary layers along the hot and cold walls, was termed the boundary layer regime. Between these two regimes the temperature profiles were observed to be curved throughout the complete height of the air layer, indicating that convection was becoming increasingly significant. This was called the transition regime. In the conduction regime heat is transferred by gaseous conduction only in the central section of the air layer. In the corners of the cavity, convection was found to contribute to the total heat flux across the cavity and local heat transfer coefficients were obtained for these corner regions. Average Nusselt number correlations for the conduction regime, as well as empirical relationships for heat transfer in the boundary layer regime, were presented.

The earliest experiments on the thermal instability phenomenon referred to above were conducted by Thomson (26), and then Benard (27) presented a more complete description of the development of a cellular convection pattern. Consequently, the thermal instability question is generally referred to as the Benard problem. Schmidt and Saunders (28) found that instability and cellular motion within a horizontal layer of fluid ensued when Ra was approximately equal to 1700. When cellular convection occurred, the length of the horizontal side of a cell was found to be approximately twice the layer depth. As Ra was increased beyond its critical value, the temperature gradients at the plane midway between the boundary surfaces decreased to negligible values, indicating that all the heat was being convected. Experiments on layers of different depths showed that on further heating the layer became completely turbulent at Ra = 4.5×10^4; the first signs of turbulence occurring at about Ra = 5×10^3.

Sadhu and Probert (29) measured steady-state rates of heat transfer outwards across vertical air-filled annular cavities, with aspect ratios which ranged from 16 to 70, and for several pressures of the contained air. The chosen temperature difference between the isothermal cylindrical walls ranged from $20^{O}K$ to $180^{O}K$. For constant values of the temperature difference, the gaseous conductive, convective and radiative components of the heat leaks across the air gap to the outer cylindrical wall were distinguished and evaluated using a technique which employed the air pressure as the variable. Convection of the air ensued throughout the whole height of the cavity when the Rayleigh number attained a value of 1.6×10^{4}.

Edwards (30) measured the rate of heat transfer through air across a rectangular sectioned cavity for different values of temperature difference across the cavity, aspect ratio, angle of inclination of the cavity with respect to the horizontal, and air pressure within the cavity. By reducing the pressure of the air in the cavity from atmospheric to 10^{-3} torr for any given geometrical arrangement, he distinguished between the convective, conductive and radiative components of heat transfer through the gas. He did not, however, distinguish between radiation through the gas and conduction via the cell structure supports. The results were presented in dimensionless form, Nusselt number against Rayleigh number.

1.5.2.2 General Review of Natural Convection in Cavities - Experimental Studies

There have been numerous investigations concerned with natural convection in enclosures. Among the references with the greatest relevance to the thesis are those of Churchill (12,31,32), Probert (8,33,34,35,36) and Ostrach (37,38). The reader is referred to Drake (39) for a more comprehensive review of more general enclosed natural convection experimental studies.

1.5.2.3 Gas Conduction in Enclosures - Experimental Studies

Most experimental studies of gaseous conduction in enclosures were (and still are) associated with work relating to thermal insulation.

A comprehensive series of experiments on the insulating effectiveness of various materials was carried out by Allcut (40) in 1951. The effects of varying the amounts of air conduction (by varying the density of the fibrous insulation materials) were studied in detail. Although no new theories or methods of evaluating air conduction were obtained, the results provided an experimental basis for future work on thermal insulation. The effects of radiation transfer, convection and air pressure were also studied.

Verschoor and Greebler (41) studied heat transfer of gas conduction and radiation in fibrous insulations. Thermal conductivity measurements were made at atmospheric pressures with four different gases in the insulation samples, and the thermal conductivity with air was studied over a pressure range of 1 micron to 760mm of Hg. Gas conduction was found to be the most important mechanism of heat transfer. A theory of gas conduction in fibrous insulation was developed, which agreed well with experimental results. Theoretical considerations of heat transfer by radiation (mean free path of radiation calculations) were also confirmed by the experimental thermal conductivity values at low pressures.

Good reviews of gas conduction studies are presented by Tye (6) and Glaser (13).

1.5.2.4 Solid Conduction - Experimental Studies

As mentioned earlier, the thermal conductivity of a material is a measure of heat flow by conduction in the material. Numerous methods are available for the measurement of the thermal conductivity of a solid material (6). The basic method is the guarded hot plate which has been the subject of much experimental and theoretical study (42,43, 44,45).

References worthy of note are Bratis and Novotny (46), Kent (23), Swann (47,48), and various workers at the seventh conference on thermal conductivity measurements (49).

Experimental analogic methods have been used to measure the solid conduction contribution to heat transfer. Schneider (5) used three different analogies (the electrical, the fluid-flow, and the membrane) to measure the solid conduction component in a furnace wall problem. Kreith (1) also describes three different electrical analogies that have been successfully used. A comprehensive review of analog methods is presented by Rohsenow (51).

1.5.2.5 Radiation Heat Transfer in Enclosures - Experimental Studies

In the last two decades, there have been numerous investigations of the influence of thermal radiation heat transfer in enclosures composed by various surfaces (black, diffuse-gray, specularly reflecting, non-diffuse non-gray, and transparent surfaces) (7,14,52,53). The majority of the publications have been analytical investigations using gas models such as the gray gas, the box or the exponental wide-band model.

At the present time, there are very few existing experimental investigations concerned with radiative transfer in enclosures. Most of these experimental investigations deal with gaseous radiation interactions (54,55,56,57,58).

Allcut (40), Verschoor (41) and Strong (59) measured the effect of thermal radiation in conjunction with thermal insulation studies in fibrous materials. Swann (4) and Stroud (60) measured the effects of thermal radiation in enclosures in their studies of heat transfer across honeycomb core panels.

Sadhu (29) and Edwards (30) in their experimental studies of natural convection in enclosures, measured the amount of radiation flux as well.

1.5.2.6 Concluding Remarks on Experimental Methods of Analysing The Cavity Problem

(a) Conduction - gas conduction has been measured by reducing the working pressure to 10^{-3} torr (13,29,30). Solid conduction is either lumped together with thermal radiation (23,29) occurring in the enclosure, or is reduced (consequently ignored) by using thin walls (61). Other workers (3, 30) used adiabatic cell set-ups and estimated solid conduction as a loss in heat flux.

(b) Radiation - no work was found in which it was measured or stated quantitatively, it was always associated with solid conduction.

(c) Convection - most workers estimated it by using the Mach-Zehnder interferometer or by difference.

1.5.3 REVIEW OF THEORETICAL METHODS

This review of calculation methods falls into three categories:

(a) Empirical and Semi-empirical - that is, correlations.

(b) Analytical - the formal analytical approach involves the derivation of a mathematical solution for the temperature as a function of space or space-time co-ordinates. The solution must satisfy the characteristic differential equation from which it was derived, and certain initial and boundary conditions imposed by the particular problem itself. Excellent books on this approach are Carslaw and Jaeger (62), Schneider (50), Jakob (21) and Ozisik (63).

(c) Numerical - these methods are associated with obtaining approximate solutions of the steady-state and transient heat transfer equations. Their basis are usually finite difference and finite element approximations.

1.5.3.1 Radiative Transfer in Enclosures - Theoretical Studies

A general analysis of radiant interchange within an enclosure was first devised by Hottel (15). Hottel's early work showed how the problem could be solved if the associated linear equations could be solved and he suggested the use of matrix methods to do so. A different approach to the problem was offered by Poljak (21,64). Later Oppenheim (65) introduced an electrical analogy to radiant heat transfer which greatly simplified the representation of the problem and he suggested that the electrical network be solved by matrix methods similar to Hottel's. An alternate approach to the cavity problem was given by Gebhart (66). All of the above methods are basically equivalent as demonstrated by Sparrow (67); they are termed 'the net-radiation method'.

Bevans and Dunkle (68) used relaxation methods in solving the resulting equations from the electrical networks of the cavity problem. Stott and Garrod (17,69) produced a method of assessing radiation heater transfer in an enclosure surrounded by several surfaces at different temperatures and containing a number of radiating and absorbing volumes of gas. They showed that the application of an electrical analogy could be made relatively simple by the use of relaxation methods to solve equations describing the analogous electrical resistive network. A computer program was described which solved the problem in general terms and its application to furnace design was outlined.

The net radiation method is formulated in different terms in the various textbooks (51,70), but the basics of the methods are the same. Wiebelt (136) developed integral equations of radiant heat transfer. These equations were solved by numerical and analytical methods. The numerical methods involved taking finite difference approximations for the integral equations which led to the network concept and hence iterative solving techniques. The analytical approach involved solving the integral equations by successive substitution and variational calculus.

An alternate approach to the analysis of radiative transfer in enclosures is offered by the Monte Carlo method. It is a statistical numerical method. A review of the problems solved in the literature using this method is given by Siegal (14).

Analytical and numerical studies of the interaction of thermal radiation with other modes of heat transfer in enclosures is well reviewed in the work of Novotny (46,56,58).

1.5.3.2 Conduction Heat Transfer - Theoretical Studies

The study of conduction heat transfer is principally concerned with the distribution of temperature or rate of heat flow within a medium. The determination of the temperature field or heat flux constitutes a complete solution.

1.5.3.2.1 Analytical solutions of conduction problems

Analytical solutions are limited in their range of applicability due to their complexity and uncertainty as far as practical boundary conditions are concerned. Many practical two- and three-dimensional engineering problems require numerical methods for their solution. However, assumptions can usually be made in most practical problems which reduce them to simple geometrical shapes with straightforward boundary conditions for which many analytical solutions have been tabulated.

The classical works on analytical heat conduction are considered to be those of Fourier (71) and Carslaw and Jaeger (62). Fourier, of course, laid the foundations of conduction in solids, while Carslaw and Jaeger later described numerous solutions to many different geometries and solutions. This latter work is principally an operational text in that the mathematical methods of solution are only briefly outlined. Carslaw and Jaeger were principally concerned with conduction for its own sake, but other authors such as Arpaci (72) have outlined conduction in an engineering context with the solutions described in more detail.

This work can in no way attempt a complete presentation of the analytical methods available for the solution of the heat conduction problems. What is attempted is a citation of some of the more commonly used and more straightforward procedures employed in engineering practice.

Schneider (50) solved various practical engineering problems using analytical methods, principally Fourier series. One of the problems that he solved that is particularly applicable to this work is that of a temperature field in a nuclear reactor. The solution obtained was only approximate as he used circular harmonics.

The classical approach to an exact solution of the heat conduction equation is the separation-of-variables technique. Kreith (1), Bayley (73) and Myers (74) have given good accounts of this approach. Myers in his text has given a fairly complete and rigorous presentation of alternative methods used in the integration of partial differential equations. An outline of the mathematical principles required to solve analytical problems is given. Bessel function, Fourier series and Laplace transforms are all presented in simple terms. Examples of the application of these principles to such problems as plane wall and semi-infinite solid conduction are given.

Rohsenow (51) also gives an excellent review of mathematical and practical examples of analytical methods used in conduction heat transfer. A systematic and unified study of methods for solutions of heat conduction problems is given by Ozisik (63). The feature of his book is a systematic tabulation of transforms; inversion formulas for finite, semi-finite and infinite regions, for all combinations of boundary conditions. Through the use of this integral transform technique, the solution of heat conduction problems becomes a comprehensive study.

1.5.3.2.2 Numerical methods

These are methods of obtaining approximate solutions to the heat conduction equation. Most treatments of numerical heat conduction are derived from the more generalised and more rigorous approach of the numerical analyst as advocated by Fox (75), Smith (76), Ames (77), Forsythe (78) and Richtmyer (79). Of the numerical approximation methods available, those employing finite difference approximations are straightforward, are more frequently used, and are generally more applicable than any other. Accordingly, this thesis concentrates on the finite difference approach. However, also briefly described is a relatively new approach known as the 'finite element' method, which is essentially a variational approach since the solution of the governing differential equation is obtained by minimising some integrated quantity (referred to as a functional) which is evaluated over the whole region of interest.

This method is widely used in structural analysis and although it is not as straightforward conceptually as the finite difference approach, it offers several advantages in the treatment of heat conduction problems, particularly with curved boundaries and normal derivative boundary conditions.

It is common in heat transfer to treat steady-state conduction (involving two or more space variables) and transient heat conduction (involving one or more space variables and time) separately, and this is also done in the numerical analysis of these problems since they form separate classes of partial differential equations. These classes are important in that they classify the nature of the procedure used in their solution. Steady-state problems are elliptical partial differential equations and transient are parabolic. Only solutions of the former are considered in this work.

(I) Finite Differences

(a) Approach - the basic approach consists of overlaying the area of integration with a mesh (usually rectangular or triangular), and in replacing each derivative of the original partial differential equation by a finite difference approximation at each mesh point, in terms of the temperatures of the neighbouring mesh points and writing down an algebraic equation approximating the partial differential equation at that point (80,81,51).

With steady-state heat conduction this process gives N simultaneous algebraic equations for N mesh points in the region, the solution of which provides a numerical value of temperature for each mesh point. In the case of transient heat conduction, the partial differential equation is approximated along one or two rows of mesh points at a time, so that the procedure results in the successive solution of small sets of algebraic equations (51,82).

(b) Physical formulation - the first step in the physical formulation of the problem is to subdivide the system into a number of small but finite subvolumes (1,51, 74,80). Each subvolume is assumed to be at the temperature corresponding to its centre. The physical system is replaced by a network of fictitious heat-conducting rods between the centers, or nodal points, of the subvolumes. Once the thermal conductance corresponding to the conductance of the material between nodal points is assigned, the heat flow in the rod network is obtained. This heat flow approximates the flow in the continuous system.

(c) Finite difference approximations - the fundamental operation in the method of finite differences is the replacement of each derivative in the partial differential equation by an algebraic approximation at each discrete point in the region. These finite difference approximations can be of varying degrees of accuracy and can be derived in several different ways: by examination of the heat flow in a differential element, from variational considerations (78) by fitting polynomials through the function values of the neighbouring nodal points and differentiating, or by the use of Taylor expansions. Myers (74), Bayley (73) and Rohsenow (51) have shown that the latter method is brief, simple, and gives an indication of the accuracy of the approximation.

(d) Formulation of nodal equations - numerous examples exist of the finite difference representation of the main equations. Among the references worthy of note are the works of Dusinberre (80), Kreith (1), Rohsenow (51) and Myers (74). In all these references, radiation and convection boundary conditions, and irregular physical boundaries are considered in detail.

(e) Finite difference equations and their solutions - finite difference methods for solving steady-state heat conduction problems lead to systems of algebraic equations. The solution of the equations is not a trivial matter. In the majority of cases, the equations are linear, so that the coefficients are constants or functions of the independent variables only, and the mathematical procedures of matrix algebra apply. However, some problems, such as those involving temperature-dependent thermal conductivity, and the cavity problem, produce non-linear algebraic equations. The methods of solving the equations can be classed as either direct or iterative.

Emmons (81) presented one of the earliest solutions to the finite difference equations by using the relaxation method of Southwell (83,84). Later, Dusinberre (80) generalised the solutions due to Emmons. Numerous publications (50,51,73,74,1) have represented the relaxation solution. The most common direct method of solution of finite difference equations is via Gaussian elimination.

Bayley and Myers present good accounts of this method. Iterative methods of solution include Gauss-Siedel (relaxation method), Jacobi, successive overrelaxation, and alternating direction implicit methods (50,51).

(II) Finite Elements

The finite element approach was developed and has been extensively used for structural analysis (85,86). It is becoming of increasing importance in other engineering fields such as fluid mechanics and heat conduction (87,88,89).

While the finite difference method represents a direct approach by approximating individual derivatives in the differential equation, the finite element procedure is an approximation applied to the variational form of the partial differential equation, so that, in general, the problem becomes one of finding a function which minimises a 'variational functional' over the field of interest.

The region is divided into a number of elements (usually triangular (86,90) for two-dimensional problems, or tetrahedral (88) for three-dimensional problems), and the unknown function is uniquely specified throughout the field by a discrete number of values associated with the node points of the elements. The value of the function at a particular node point influences only the function at the nodes of the adjacent elements so that the minimization of the functional throughout the whole region results, as with finite differences, in a system of simultaneous equations.

Numerous investigators have dealt with the fundamental concepts of the finite element method. The papers by

Zienkiewicz (85,88) present the finite element formulations well. More recently, Myers (74) has dealt with the subject very fully. Fundamental concepts are presented and two-dimensional steady-state problems are solved. Bayley (73) has used the finite element method to solve the classical gas turbine problem. Zienkiewicz (88) used finite element methods to solve electrical three-dimensional field problems which are analogous to heat transfer problems. He also studied spontaneous ignition (89) using variational techniques.

(III) Concluding Remarks on Finite Difference and Finite Element Methods

Emery and Carson (90) made a study of the accuracy and efficiency of the finite element methods in comparison to the standard finite difference algorithms used for the computation of temperature. Their study was primarily concerned with computational aspects, but their general conclusions seemed to favour the use of the finite element methods rather than finite difference ones. Their study suggested that the primary advantages of the finite element methods were associated with the ease of inputting the required data and the capability of altering the basic accuracy of the method; its major disadvantages were large core memory requirements and lengthy execution times.

Bayley and Myers, both make the points that, although the finite difference and finite element methods occasionally result in identical equations, the finite element method has advantages in the freedom of the shape of elements (that is, the choice of placement of node points in complex regions) and in the ease with which derivative and mixed boundary conditions on irregularly shaped boundaries can be handled.

1.5.3.2.3 Other methods of obtaining approximate solutions

The theory of complex variables provides the means of obtaining solutions to two-dimensional steady-state heat transfer problems in many situations where analytical procedures are not applicable. The most useful aspect of this theory is its ability of transforming a region in which heat transfer takes place (where, for example, complicated boundary conditions prohibit the use of analysis) into another region, so that the problem can be easily solved (91,92,93). This transformation, which preserves the magnitude and sense of the angles between isothermal boundaries, is called conformal mapping. This theory also provides the fundamentals for graphical solutions. Kreith (1), Schneider (50) and Rohsenow (51) have used graphical methods to solve numerous conduction problems.

1.5.3.2.4 Solutions of transient state problems

Unsteady-state heat transfer problems are characterised by time-dependent heat fluxes and temperature fields. Exact solutions to most practical transient heat transfer problems are rather difficult, if not impossible, to obtain. Thus, the necessity of obtaining an approximate solution to such problems has motivated a considerable effort for developing methods for achieving approximate solutions. The most commonly used of these methods can, in general, be classified in the following four categories:

(1) Method of finite differences - this method has attracted most of the attention in recent years, primarily because it is easily adapted to digital computations (94); consequently, this is the only method that can be used to obtain an approximate solution if a high degree of accuracy is required, or it the problem at hand is of considerable size and complexity.

(2) Graphical methods - were first introduced by Schmidt and Binder (15). In recent years, with the development of computers, the interest in such methods has diminished, though these methods can provide quick answers, and also have the advantages of simplicity and visualization.

(3) Approximate analytical methods - several have been developed (51,73) for obtaining approximate solutions of heat transfer problems in an analytical form. They can be applied to both linear and non-linear problems yielding simple solutions with an accuracy adequate for engineering purposes. The most extensively used are the Integral method first introduced by Goodman and the Biot's variational principle.

(4) Analog methods - these are discussed by Paschkis (51) in great detail.

1.5.3.3 Review of Convection Heat Transfer - Theoretical Studies

As it was the aim of this work to suppress convection in the cavity, the theoretical studies on natural convection pertinent to this study are concerned with heat transfer in the conduction regime only (Ra less than 1709). With this restriction, little work has been found which is directly applicable.

Natural convection studies in enclosures can be classified as follows:

1.5.3.3.1 Empirical studies

Most of the experimental and numerical investigators of heat transfer in enclosures, presented their results in the form of the Nusselt number - Grashof (or Rayleigh) number correlations (25,70,95,96.97,98). The most up-to-date correlation (May 1976), is that due to Holland (114). The correlation is applicable for all values of the Rayleigh number and agrees well ($\pm$ 5%) with experimental results for angles of inclination to the horizontal less than 60 degrees.

$$Nu = 1 + 1.44\ (1 - 1708/Ra \cos \phi)(1 - \frac{(\sin 1.8\phi)^{1.6} 1708)}{Ra \cos \phi}$$
$$+ \left(\left(\frac{Ra \cos \phi}{5830}\right)^{0.333} - 1\right) \qquad (1-5)$$

where Nu = Nusselt number for natural convective heat transfer across the air layer

Ra = Rayleigh number

ϕ = Angle of air layer from horizontal

1.5.3.3.2 Analytical and numerical studies

(A) Vertical layers

Early theoretical analyses of the cavity problem were published by Batchelor (99) and Poots (100).

Batchelor presented a solution valid for nearly square enclosures based on parametric expansion of the temperature field and stream function in powers of the Rayleigh number. As such, his results were valid only for small Rayleigh numbers or the cases where conduction predominated convection. Poots used a numerical method based on the use of orthogonal polynomials to solve a variant of the cavity problem in which the temperature profiles along the top and bottom of the enclosure varied linearly between the source and sink temperatures. Results were presented for aspect ratios of unity, Pr = 0.73 and Rayleigh numbers from 500 through to 10,000. The Poots' correlation was

$$Nu = 1 + (9.8 \times 10^{-8})\ Gr^2 \qquad (1\text{-}6)$$

provided the Grashof number was less than 1390. This result compared favourably with Batchelor's predictions.

Mynett (101) attempted to solve the governing equations by means of a relaxation technique for an aspect ratio of 6 only and for Rayleigh numbers of 100, 1,000 and 10,000 respectively. The partials differentials were replaced by their finite difference equivalents in preparation for the relaxation process, which involved an iterative procedure. The results obtained for Nu agreed closely with those of Batchelor's.

Following Eckert and Carlson (25), various publications (95,102,103,104,105) have used the temperature distribution in the cavity to distinguish between three regimes of flow. At Ra less than 3,000 the computed temperature profile across the cavity was virtually linear, that is, the continuum conduction regime. As Ra increased, convection was found to become increasingly significant and the temperature profiles across the air layer flowed a progressive departure from linearity - this is termed the transition regime. Above Ra = 10,000, the boundary layer regime ensued.

(B) Horizontal layers

The first analytical treatment aimed at determining the conditions delineating the breakdown of the quiescent state within horizontal fluid layers heated from below was carried out by Lord Rayleigh (106). This work was corroborated and extended by Jeffreys (107,108) and Low (109). From these analyses it was concluded that the sole parameter determining stability was the product of the Prandtl and Grashof numbers, that is, the Rayleigh number. The critical value of Ra (based on the thickness of the flüid layer), above which cellular convection ensues, was computed to be 1709. The fundamental assumptions in these analyses were that (a) density variation effects were negligible except for their influence on the bouyancy; (b) the initial motion was slow; and (c) a linear temperature profile extended across the entire fluid layer at the start of the motion.

More recent studies on convection in enclosures include the work of Churchill and Chu (110). They studied the effect of localised heating in a rectangular channel by solving the partial differential equations for the conservation of mass, energy and momentum numerically using an unsteady-state formulation and the alternating-direction-implicit method. The computations were carried out for Pr = 0.7 and Rayleigh numbers between 0 and 100,000. They concluded that (a) the relationship between the circulation pattern and the rate of heat transfer was quite complex and (b) conduction was the predominant mechanism for heat transfer for Ra less than 1,000 even though some circulation occurred for all Ra greater than 0.

Ozoe and Churchill (12) performed a three-dimensional numerical analysis of laminar natural convection in a confined fluid heated from below. They tested three geometrical configurations and compared their results with those of Aziz and Hellums, Catton, and Heitz and Westwater. For the cubical enclosure, the critical Rayleigh number obtained by extrapolation to Nu = 1 was 3500, which agrees closely with the computed value of 3446 by Catton (111), and the experimental value of 3700 by Heitz and Westwater (112). For the long square channel, the critical Rayleigh number obtained from extrapolation to Nu = 1 was 2300 which agrees reasonably well with the prediction of 2452 by Catton. The results for the analysis of a region between infinite horizontal plates heated from below gave similar results as obtained from earlier two-dimensional computer programs (31).

1.5.3.3.3 Theoretical convection studies in the post conductive regime

Catton (113), Hollands (114) and Buchberg (18) give good reviews of the work that has been done in this area in the last two decades.

1.5.3.3.4 Concluding remarks on natural convection studies in enclosures

It has been conclusively shown by Probert (11) for vertical air layers, that the limit of conduction can be identified solely in terms of the Grashof number ($Gr = 2.2 \times 10^3$) and that the critical Grashof number is independent of the height of the fluid layer.

Rayleigh (106), Jeffreys (107,108) and Low (109) have shown that for horizontal fluid layers, the critical Rayleigh number is 1709. The studies of Ozoe and Churchill (12) tend to come up with critical Rayleigh numbers close to 2300 for confined fluids heated from below.

1.6 METHOD OF SOLUTION

The cavity problem is solved in this work by two distinct methods (a) by an experimental method and (b) by a numerical method.

1.6.1 METHOD OF SOLUTION BY EXPERIMENT

The experiment is required to measure or show the effects of: (a) the thermal conductivity of the specimen; (b) solid conduction; (c) thermal radiation; (d) gaseous conduction; and (e) total heat flow.

1.6.1.1 Convection

As previously mentioned, it was the aim of this work to suppress natural convection. Consequently, all the experiments were to be performed at sub-critical Rayleigh numbers (less than 1700). As calibration runs will show later, by working with specimens of less than 0.75 inches (19.05mm) thick at moderate temperatures, the resulting Rayleigh and Grashof numbers are sub-critical. As no interferometer was available, the no convection assumption could not be checked experimentally.

1.6.1.2 Radiation

Radiation is difficult to measure experimentally (115). As such, the only ways of assessing its importance are by difference or by showing its varying effects under different conditions. Since conduction and convection were not measured individually or distinguished in this work, the latter method was used. Radiation effects were assessed by varying the

(i) material
(ii) material thickness
(iii) cavity size
(iv) temperature differences across the cavity
(v) surface conditions at the ends of the cavity

1.6.1.3 Conduction

Solid conduction could have been measured by imbedding thermocouple wires in the solid slabs used. The introduction of these probes in the solid would have disturbed the heat flux profiles (see section 1.6.3).

Gas conduction could also have been measured by varying the working pressure (below 10^{-3} torr gas conduction negligible (13,30)), however, evacuating holes in the specimens would also have been necessary. They too would have disturbed the heat flow.

Consequently, conduction effects were also only assessed in relation to the total heat transferred under various experimental conditions (see 1.6.1.4 below).

1.6.1.4 Total Heat Transferred

The total heat flow was determined using a guarded hot plate apparatus (5). For a given temperature difference and material, the apparatus was used to measure the thermal conductivity of the material. Holes were then drilled in the specimen. The guarded hot plate apparatus was again used to find the total heat transferred at the same temperature differences as for the solid specimen experiments. This set of experiments was repeated for various hole sizes, thicknesses of the same material, and for various materials. By blocking the holes with aluminium foil, the effects of radiation were also assessed.

From quantitative heat flux curves of heat transferred against temperature difference for various operating conditions, the effects of solid and gaseous conduction can be distinguished from radiation effects, as the former are linear relationships while the latter are non-linear. A comparison of total heat transferred by experimental and by theoretical work provided a check on the accuracy of the theoretical and experimental analyses.

1.6.1.5 General Remarks

The primary material used in the experiments was 'perspex' acrylic sheet (Imperial Chemical Industries Limited tradename for polymethyl methacrylate). Rationale for this choice, is provided in the next chapter. Other materials used are particle board, rubber, and two types of asbestos cement board (durotherm and syndanyo board).

1.6.1.6 Assumptions

Some of the basic assumptions used in the development of the experimental method of solution are summarised below. Other particular assumptions are discussed as they arise.

(a) Steady-state conditions exist - the recorder showed this condition to be true despite fluctuations in voltage and current which could not be eliminated.

(b) Uni-directional heat flow - the thermocouple wires on each plate proved this to be practically correct.

(c) Heat flow from electrical power input is equally divided between the two specimens. Electrical power was computed from current multiplied by voltage assuming a power factor of one. Also the heat flux was assumed to be area dependent, that is, since the central metered section was 1/4th of total plate area, then 1/4th of the power was associated with this area.

(d) The temperatures indicated by the thermocouple wires are the correct surface temperatures (see section on surface temperature measurement).

(e) The surface temperature of the specimen at the hot end is equal to the surface temperature of the hot plate of the guarded hot plate apparatus. Similarly for the cold end of the apparatus, the specimen temperature is assumed to be the same as the cold plate temperature.

1.6.2 NUMERICAL SIMULATION OF THE EXPERIMENTAL SET-UP

1.6.2.1 Theoretical Basis

1.6.2.1.1 Assumptions

The basic assumptions used in the numerical simulation of the cavity problem are:

(1) Steady-state conditions exist

(2) No heat generation - heat sources or sinks in the problem are non-existent

(3) The physical properties of the system are constant and are calculated at the mean temperatures. For example,

the thermal conductivities of perspex and air are constant (at the mean temperatures).

(4) Zones of constant temperature are associated with each node. Three different zoning systems are used (see Appendix). For solid conduction, the zoning approximations are well known (1,50). For gas conduction, cores of air at constant temperature are considered. For radiation surfaces, the zoning approximations of Hottel (116) are assumed.

(5) The surfaces of the enclosure are assumed to be opaque and diffuse-gray (Appendix). Hence, the emissivity of perspex is taken as 0.9, and that of aluminium taking values of 0.04, 0.11, 0.2 and 0.5 (Appendix).

1.6.2.1.2 Basic transfer equations

The basic equation used for the conduction flow calculations is the Fourier equation (1-1) in three dimensions. For radiant transfer, the Stefan-Boltzmann equation (1-3) is used. The continuity and mass conservation equations are used in all heat balances. Note that for radiant heat transfer in the enclosure, the net-radiation method (14,64) is applied.

1.6.2.2 Numerical Solution of the Cavity Problem

1.6.2.2.1 General description of the procedure

The method used is an iterative one using relaxation techniques. Unknown temperatures are first estimated and the radiation fluxes between radiation regions are calculated. Using these fluxes, heat balances are calculated for each region and temperatures are adjusted until the heat balances are satisfied. The procedure is repeated until no further worthwhile changes occur. The calculation depends for its success on a technique (discussed later) which ensures convergence of the iterations which calculate the heat balance, whilst simultaneously adjusting the radiation flow changes due to changes in temperature. The convergence, accuracy, and numerical stability of relaxation procedures is well documented in the literature (80,81).

1.6.2.2.2 Problem formulation - finite difference approximations

(a) Heat transfer equations

(i) Choice of grid - the three-dimensional cartesian co-ordinate system used (rectangular parallel-piped or box elements) is shown in the Appendix. The relationship of the grid to the physical layout of the problem is also presented. There are three solid conduction regions, each region has 58 temperature points. Note that due to the symmetry of the problem, only 1/8th of the box element (or zone) is used. Six radiation regions are considered and three air conduction regions (each with four temperature (nodal) points).

The choice of grid presented numerous problems as the hole (or cavity) is cylindrical whereas the solid is rectangular, hence mixed co-ordinate systems at the air-solid interface were necessary. As will be shown later, by using triangular meshes at this boundary, the problem was solved.

(ii) Boundary and initial conditions - at the hot end of the cavity, the temperature was fixed at the experimentally obtained value. At the cold end of the cavity similarly, the temperature was fixed at T_{cold}. All the other boundaries were taken as zero heat flux regions. In the computer program this was done by putting the conductances associated with fictitious temperatures at zero conductances.

The initial temperatures within the grid were arbitrarily chosen.

(iii) Formulation of the nodal equations - detailed derivations of the equations are given in the Appendix. After completing the subdivision of the system, the thermal conductance K_{ij} between the nodes i and its adjacent j nodes must be calculated. The rate of heat flow q_{ij} (watts) from any node j to the adjacent node i is:

$$q_{ij} = K_{ij} (T_j - T_i) \qquad (1\text{-}7)$$

The heat balance for the node i gives the equation:

$$\sum_j q_{ij} = \sum_j K_{ij} (T_j - T_i) = 0 \qquad (1\text{-}8)$$

Using this energy-balance method, equations of the type shown below were obtained for the temperature (T_{299} - Figure B4) of an interior node:

$$\frac{\{CXY(298)T(298)+CXY(299)T(300)+CYX(425)T(425)+CYX(299)T(173)+CZX(285)T(285)+CZX(299)T(313)\}}{\{CXY(298)+CXY(299)+CYX(425)+CYX(299)+CZX(285)+CZX(299)\}} - T(299) = 0 \qquad (1\text{-}8A)$$

For a surface point, for example, nodal point 158, the radiation heat flow, and the air heat flow had to be taken account of.

Air conduction toward (or away from) the surface is evaluated using equation (1-7). The radiation exchange within the enclosure is analysed using the net-radiation method. The basic heat balance equations for the net-radiative loss from surface k resulting from radiation in the enclosure are:

$$Q_k = A_k \frac{\varepsilon_k}{(1 - \varepsilon_k)} (\sigma T_k - q_{o,k}) \qquad (1\text{-}9)$$

and

$$Q_k = A_k \left(q_{o,k} - \sum_{j=1}^{N} F_{k-j}\, q_{o,j}\right) \qquad (1\text{-}10)$$

where Q_k = net radiative loss from surface k, W

ε_k = emissivity of surface k

A_k = area of surface k, M^2

$q_{o,k}$ = total radiation leaving surface k, that is, the radiosity, W/M^2

F_{k-j} = configuration factor

k,j = property of surface j or k

N = number of surfaces in the enclosure

Equations (1-9) and (1-10) are written for each of the six surfaces in the enclosure. This provides 12 equations for 12 unknowns. The radiosities ($q_{o,k}$) are the six unknowns. The remaining six unknowns are the Q's (since the radiation regions temperatures are assumed (or guessed)). As shown in the Appendix, the Q's are eliminated giving six equations relating the six unknown q_o's and the T's. The resulting system of equations is:

$$\sum_{j=1}^{6} (\delta_{kj} - (1 - \varepsilon_k) F_{k-j})\, q_{o,j} = \varepsilon_k \sigma T_k^{4} \qquad (1\text{-}11)$$

With the temperatures given, the q_o's can be found from (1-11) and on substituting in (1-9), the radiation flows Q_k in the cavity are known.

Once the radiation flows in the cavity are known, using the energy-balance method, equations of the type shown below can be written for all surface points. The equation written below is for surface point 158 - Figure B3; the factor dQ_r/dT arises in getting the solution to converge as discussed in the next section.

$$Q_{r,3}+(dQ_r/dT)_{158}(T(158)-T_i(158)+K_{air,158}(T_{air}-T(158)) =$$

$$CXY(158)(T(158)-T(159))+CZX(158)(T(158)-T(172)+CYX(158)$$

$$(T(158)-T(32))-CYX(284)(T(284)-T(158)) \qquad (1\text{-}12)$$

where $Q_{r,3}$ = radiation flow towards surface point 158

$T(158)$ = temperature of surface point 158 (to be relaxed)

$T_i(158)$ = initial temperature of surface point 158 (before relaxation)

K_{air} = thermal conductance of air associated with surface point 158

$(dQ_r/dT)_{158}$ = approximate change in radiation flow with temperature nodal point 158

the other variables are as described in the nomenclature section

In the computer program, a general expression (equation) was used for determining the nodal equations of interior, surface, and air points (see Appendix).

(b) Thermal conductance equations

For interior points conduction, the thermal conductances are calculated using the formula:

$$K_{ij} = k \left(\frac{A_{ij}}{L_{ij}}\right) \qquad (1\text{-}13)$$

where k is the thermal conductivity

A_{ij} is the average surface area perpendicular to the direction of heat flow

L_{ij} is the distance between the nodes

The irregular boundaries produced as a result of the presence of the circular hole in the box element used for calculations required special treatment. The thermal conductance between such nodes was calculated by the unified method of Macneal (117). A justification of the use of this method is presented in the Appendix.

For the air thermal conductance calculations, equation (1-13) is written in cylindrical co-ordinates.

$$K_{ij} = 2\pi k L_{ij}/\ln\ (r_o/r_i) \qquad (1\text{-}14)$$

The detailed calculations and theory of thermal conductance methods can be found in the Appendix where composite media, and boundary nodes are dealt with.

1.6.2.2.3 Solutions of the equations

(a) Radiation equations - equation (1-11) resulted in a set of six simultaneous equations. Since the right hand side was known and the left hand side consisted of a matrix of coefficients, matrix inversion (Gaussian elimination with total pivoting) was used to find the radiosities. With $q_{o,k}$ found, Q_k was found by substitution into (1-9)

(b) Heat balance equations - the heat balance equations of the form (1-8) and (1-12) are solved by successive over-relaxation. The relaxation procedure of solving potential flow networks is well known and is only briefly described here (81,83,84). The heat flows into a node are summed, and if not zero, the temperature of the function is adjusted to make the net heat flows zero. Zero net heat flows at all nodes implied the desired steady-state solution had been found.

(c) Convergence technique - as mentioned above, to solve the heat balance equations, they are relaxed, and because these equations describe a potential flow situation, the results converge rapidly.

However, when the new temperatures are used to recalculate radiant fluxes and new heat balances are calculated from these, convergence does not occur between consecutive calculations of regional heat balances and radiant fluxes. Account must be taken, at least approximately, of the change in radiant flux as the temperature being relaxed is changed in the heat balance equations. The method of doing this is as follows.

It has been shown (17,69) that by considering the matrix of equations describing radiant fluxes in the electrical analogy, for any region s, $(dQ_r/dV)_s$ is constant. That is, if all the temperatures are constant, except that of region s, then the radiant flux to s is proportional to the voltage of s alone.

But $V_s = \sigma T_s^4$, (1-15)

where V is the voltage in the electrical analogy, W/m^2

From (1-15),

$$(dV/dT)_s = 4\sigma T_s^{\ 3} \tag{1-16}$$

and so $(dQ_r/dT)_s = (dQ_r/dV)_s \; 4\sigma T_s^{\ 3}$ (1-17)

Since the radiation flow in the cavity is known before each set of iterations starts, $(dQ_r/dT)_s$ for each region is also known by evaluating equation (1-17). Hence equation (1-12), that is, the surface points heat balance can be solved. In this treatment, (dQ_r/dT) is regarded as being constant during the iteration.

1.6.2.2.4 Program flow sheet

The block diagram of the computer program used to solve the cavity problem is shown in Figure 1-2.

1.6.2.2.5 Reliability of solutions

In the simulation runs, the heat balances were attained to within 0.03%. The grid size was reasonable. It covered all the regions of the cavity problem well (Appendix). The configuration factors used were derived as shown in the Appendix, they were taken for the whole ring and disk rather than for finite radiation surface areas.

1.6.3 SURFACE TEMPERATURE MEASUREMENT

1.6.3.1 General Remarks

It is widely recognised that the output of a sensor such as a thermocouple or a thermometer represents an approximation to the temperature at some location in a fluid or a solid. There is no easy method of attaching a thermocouple to a surface so that it can be guaranteed to indicate the true surface temperature. To do this, it would be necessary to mount the measuring junction so that it could attain, but not affect, the surface temperature.

(a) Measurement error - a significant difference will exist between the indicated temperature and the 'true' surface temperature, that is, the temperature that the surface would reach if no thermocouple were present. This difference is normally termed a 'measurement error', but it should not be confused with calibration or extension wire errors which are common to all thermocouple measurements. The relationship between the indicated and true surface temperature is often defined by the equation:

$$Z = (Ts - T_i)/(Ts - Ta) \qquad (1\text{-}18)$$

where Z = installation factor

Ts = true surface temperature

Ti = indicated surface temperature

Ta = temperature of the surrounding or coolant

The value of Z for a particular installation may be calculated or found by experiment.

(b) Installation - in the experimental set-up used in this work, the thermocouple junction is installed in a groove. The groove is filled with araldite so that the surface is restored to its original profile. A thermocouple in a groove normally will have its junction below the surface and will indicate the sub-surface temperature. Details on thermocouple installation of this work are described in Chapter 2.

The measuring junctions of the thermocouples used in this work are made by twisting together bare thermocouple wires and then mounting them in a groove using araldite.

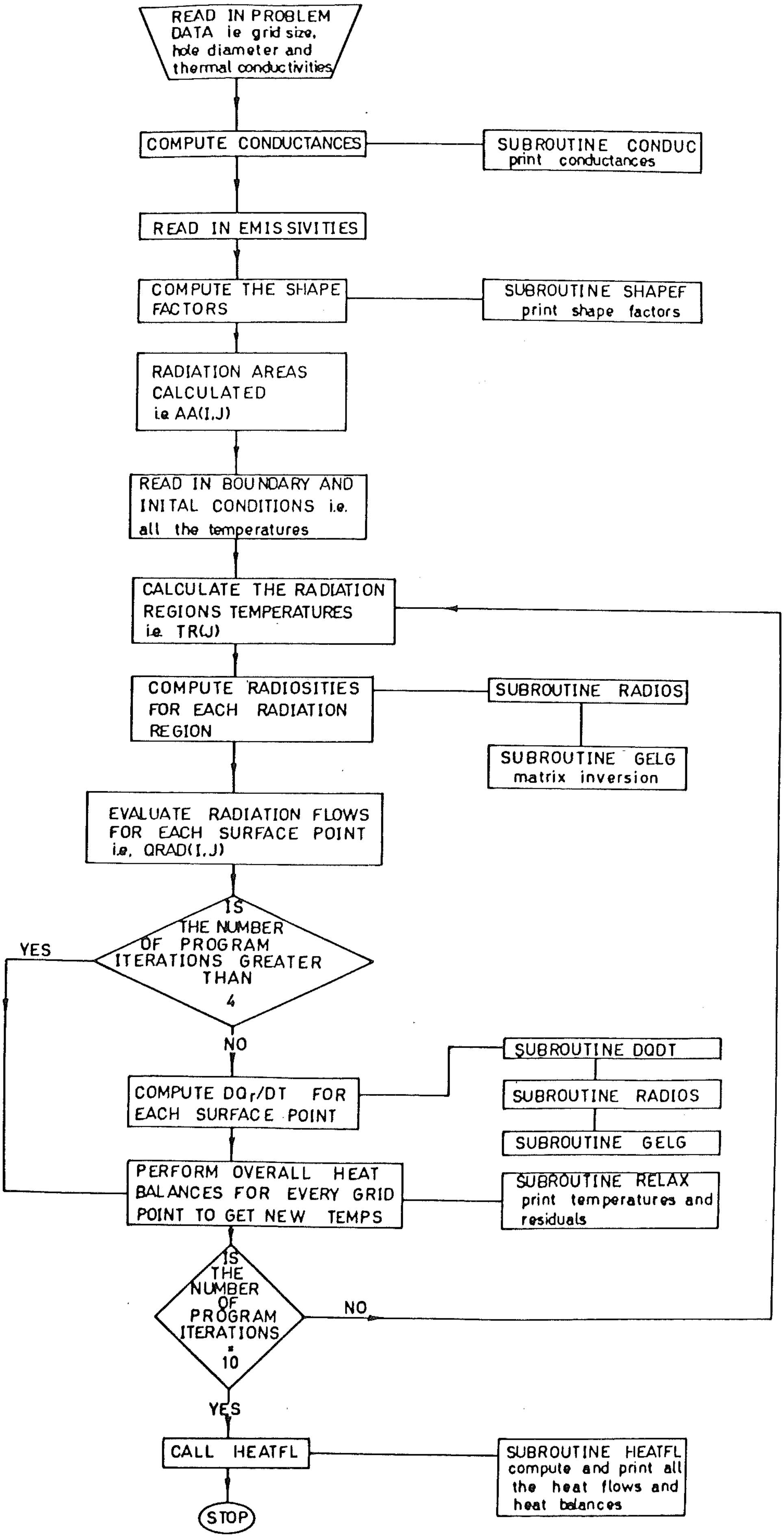


FIGURE I-2 FLOWSHEET OF THE COMPUTER PROGRAM USED TO SOLVE THE CAVITY PROBLEM

1.6.3.2 Sources of Error

When a thermocouple is attached to a surface, its presence alters the heat transfer characteristics of the surface and normally will change the temperature distribution. This causes an error which is referred to as the perturbation error.

Causes of perturbation error are:

(i) The heat transfer characteristics of the surface are changed by the installation of the thermocouple. That is, the surface emissivity and effective conductivity will be altered and/or the wires act as fins providing additional heat transfer paths - the so called 'conduction error of thermocouples' (118).

As will be shown later, the presence of another material, that is, the adhesive araldite, causes a distortion of heat flow in the immediate vicinity of the measuring junction.

(ii) Thermal contact resistance between the junction and the surface causes a temperature gradient which prevents the measuring junction from attaining the correct temperature.

Other causes of uncertainty in the measurement of surface temperatures include:

- the possibility of the thermocouple junction being in a small air pocket.

- the position of the thermocouple junction in relation to local inhomogeneities in the surface of the sample; and also the uncertainty in the exact position of the junction relative to the surface.

- different and possibly varying thermal resistances between the samples and the plates at the positions where the thermocouple wires are installed.

- although not discussed in this Chapter (see Chapter 2 and the Appendix), the errors associated with thermocouple measurements, such as deviations from standard emf and lead wire errors, must be taken into consideration.

1.6.3.3 Prior Work on Error Determination in Surface Temperature Measurement

The perturbation error must be determined if the surface temperature must be known with a high degree of accuracy. The error, and hence the correction factor, has been determined by various investigators using the following methods for steady-state conditions:

(a) Direct calculation - The direct calculation of the error involves solving the heat flow equation for the measuring junction and surface geometry (115). Simplifying assumptions are made, and the results interpreted in relation to them. Numerous publications (20,50,118,119,120) have used this approach and have clearly shown the major sources of error. They also indicated means of reducing these errors. Singh (121) recently (August 1976) used this approach to calculate the error in temperature measurements due to conduction along the sensor leads and compared theoretical results with experimental results and obtained good agreement.

(b) Analog methods - Analog methods of solving the heat transfer equations using resistance or resistance-capacitance networks have been used to indicate the overall temperature distribution (50,120,122,123). These methods have shown the perturbation effects of the thermocouple clearly. They have, however, also shown that they are difficult methods to make flexible, and so they required a number of analog models to simulate various heat transfer conditions.

(c) Relaxation methods - Although these methods have been mentioned in the literature as being suitable for error determination calculations in surface temperature measurements, no work was found that applied them. As will be shown later, they were used in this work to solve the heat transfer equations associated with surface temperature determination (section 1.6.3.4).

(d) Experimental methods - Direct experimental measurement on the installation has been found to be one of the most satisfactory ways of accurately determining the perturbation error (118). Care and precision had to be taken to simulate the service conditions exactly as changes in any variable significantly affected the results. The major problem found was in determining the true surface temperature. This has been discussed extensively in the literature (123,124,125,126,127,128).

Baker (129) has discussed surface temperature measurement techniques, errors and minimisation of errors in numerous practical installations. The work of Eckert and Goldstein (115) is noteworthy in this respect too.

1.6.3.4 Method of Solution - Surface Temperature Measurement

1.6.3.4.1 Problem statement

The objectives of this part of the thesis are:

(1) to determine whether the temperatures indicated by the thermocouple wires were the true surface temperatures.

(2) to determine the temperature profiles of the aluminium plates (hot and cold) in the presence and absence of the thermocouple grooves.

(3) to test the hypothesis that the aluminium plates were so large in size in comparison to the thermocouples, thermocouple grooves, and araldite adhesive that their presence could be ignored.

1.6.3.4.2 Assumptions

The general assumptions used in formulating the solution to the problem outlined above are:

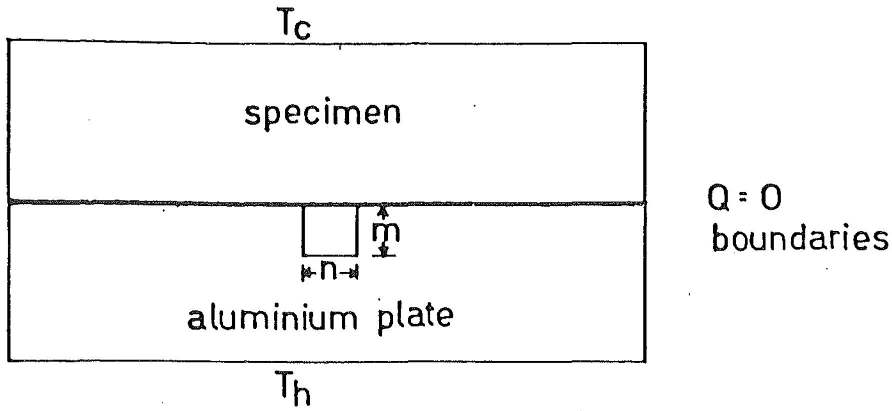
(a) most of the finite difference assumptions outlined in section 1.6.2.1.1, that is, zones of constant temperature, physical properties of the system evaluated at average temperatures, and no heat generation

(b) steady-state, two-dimensional flow

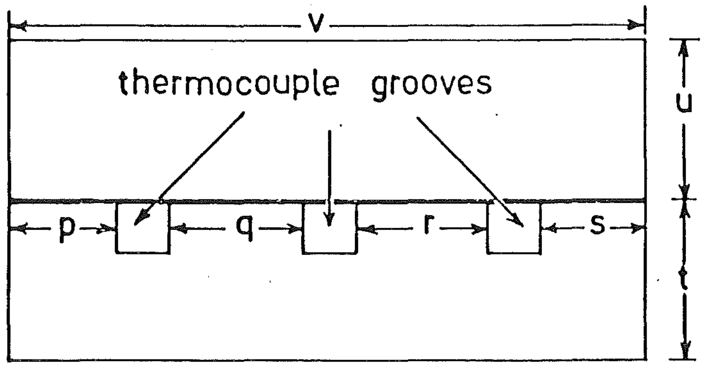
(c) zero heat flux at two of the boundaries and fixed temperatures at the other two boundaries

1.6.3.4.3 Physical formulations

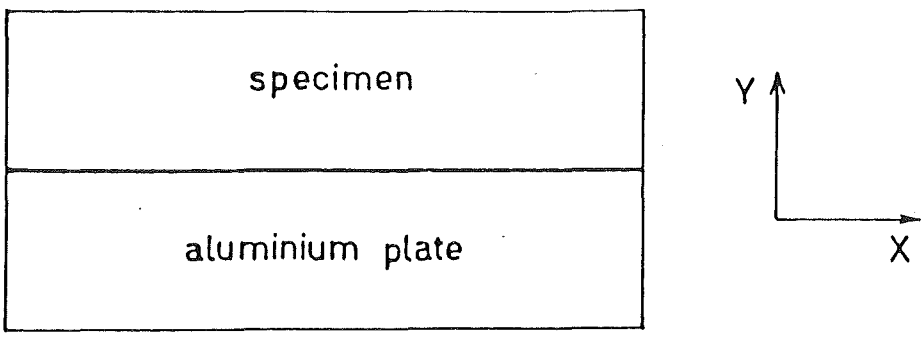
In simulating the surface temperature measurements, a cross-sectional view of the hot guarded plate apparatus was considered (see Chapter 2). Considered were three basic physical arrangements of different linear dimensions - Figure (1-3).



(A) ONE GROOVE



(B) THREE GROOVES



(C) NO GROOVES

FIGURE 1-3 SKETCHES OF THE TWO DIMENSIONAL CONFIGURATIONS USED IN THE SURFACE TEMPERATURE SIMULATIONS

(a) One groove - the aluminium plate was assumed to have only one thermocouple groove of various dimensions.

(b) Three grooves - the aluminium plate with three grooves (as used in the experiment) was considered.

(c) No grooves - the aluminium plates were assumed to have no groove (or grooves) in them. This arrangement gave the theoretically ideal results, that is, the temperature profiles that were assumed in the calculation of the results in Chapter 4.

The finite-difference approximations to the problem were set up by dividing the physical arrangements mentioned above into nodes as shown in the Appendix.

1.6.3.4.4 Mathematical formulation

(i) General description of the procedure - the method used is an iterative one using relaxation techniques. From the physical formulation, finite difference approximations are applied to the Fourier equation (1-1) in two dimensions. The resulting finite difference equations are solved using successive overrelaxation by first guessing all the unknown temperatures; the boundary conditions are, of course, known. Using these temperatures, heat balances are calculated for each region and temperatures are adjusted until the heat balances are satisfied. This procedure is repeated until no further worthwhile changes occur.

(ii) Finite difference approximations - as the only mode of heat flow in opaque solid materials is conduction, the basic heat transfer equation used is the Fourier equation. Consequently, the nodal equations are derived from equations (1-7) and (1-8). Using the heat balance method for a region, the resulting relaxation equating is of the exact form as equation (1-8A). The only difference is that now it is in two dimensions and not three, hence fewer terms.

Applying equations (1-7) and (1-8) to nodal point i+m for example, the resulting relaxation equation is:

$$\frac{(CA_{i+m-1}\ T_{i+m-1}) + (CA_{i+m}\ T_{i+m+1}) + (CU_i\ T_i) + (CU_{i+m}\ T_{i+2m})}{(CA_{i+m-1} + CA_{i+m} + CU_i + CU_{i+m})} - T_{i+m} = 0 \tag{1-19}$$

where m = number of nodal points in the x-direction (Figure 1-3)

CA_i = thermal conductance between nodal points i and i+1 in the x-direction, $W/^{o}C$

CU_j = thermal conductance between nodal points j and j+m in the y-direction, $W/^{o}C$

T_k = temperature of nodal point k in degrees celsius

As shown from Figure 1-3, the specimens considered are rectangular in cross-section, consequently, the choice of grid was no problem, a rectangular grid was used. The various sizes of the mesh are shown below. In all runs, nodal points were concentrated in regions of high temperature gradients.

The boundary conditions used were zero heat flux at the edges as indicated in Figure 1-3. To obtain the boundary temperatures, fictitious temperature nodes were used whose thermal conductances were put at zero, and their equations were neither formulated nor relaxed (see Appendix). In a few runs, the boundary conditions of constant edge temperature were used in attempts to verify the program.

(iii) Thermal conductance equations - the equations used for evaluating the conductances are exactly the same as those used for the cavity problem solutions, that is, equation (1-13).

1.6.3.4.5 Numerical solution of the equations

All the equations obtained are of the form of equation (1-19), that is, they are linear heat balances. As previously mentioned, successive overrelaxation was used to solve them.

The program flow sheet used to solve the equations is shown below.

1.6.3.4.6 Numerical simulations carried out

Numerous computer runs were used to simulate the surface and experimental conditions (both physical and thermal conditions), in order that surface temperature profiles, and true surface temperatures could be obtained. In this work, only a few of these simulation runs are presented. Sixteen different simulation runs are presented in two parts. The first part consists of runs numbered 1 to 10. These simulate conditions that are not used in the experiment, but are physically close to the experimental conditions. For example, runs 1 and 2 simulate thermocouple grooves of linear

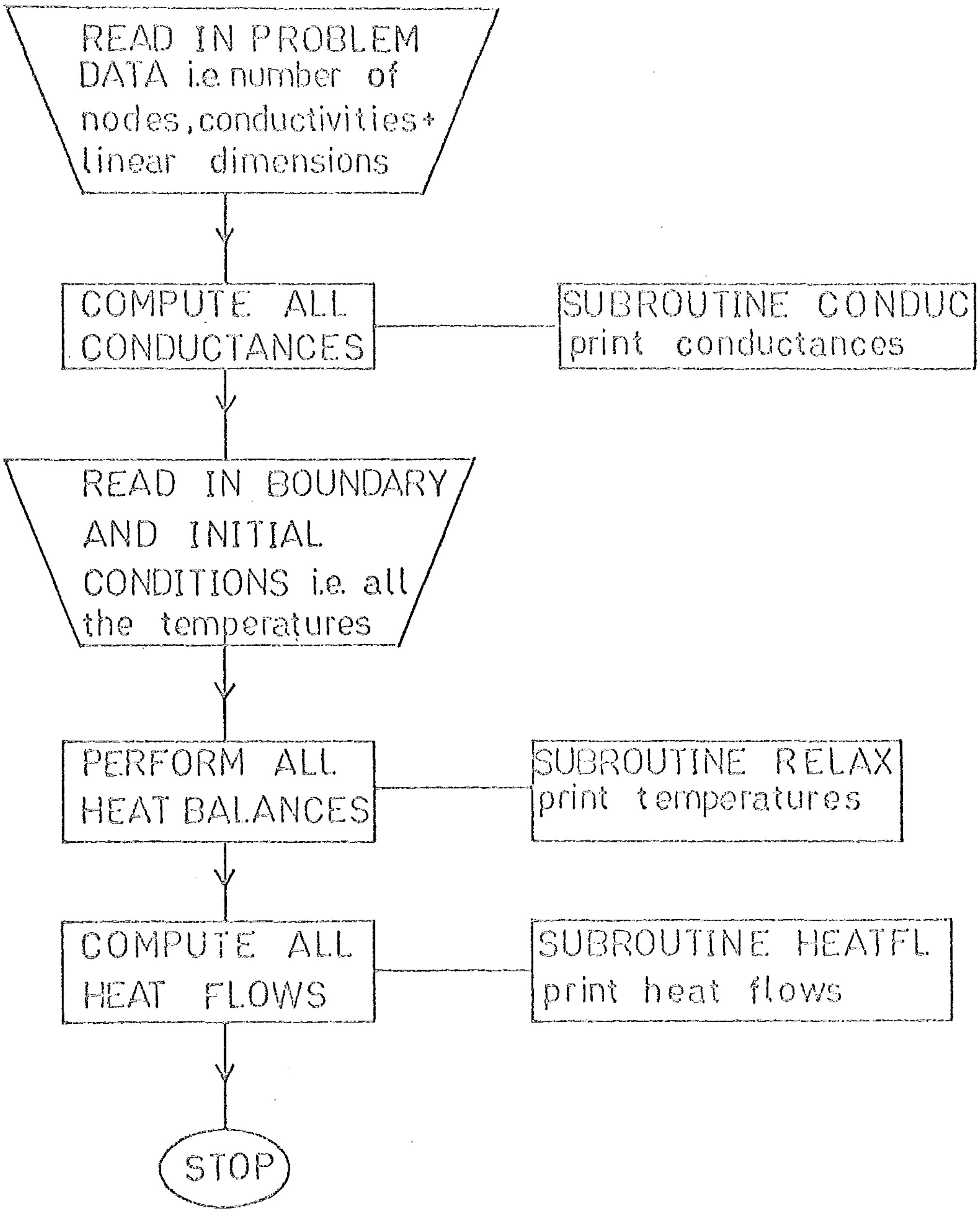


FIGURE 1-4 FLOWSHEET FOR SURFACE TEMPERATURE SIMULATION PROGRAM

dimensions 5mm by 5mm. In the experiment, the actual size of the grooves is 2.38mm by 2.38mm. Simulation runs numbered 11 to 16, correspond exactly to the experimental conditions. For example, run 12 uses thermocouple grooves of 2.38mm by 2.38mm. These runs (11 to 16) make up the second part of the simulation.

SIMULATION RUNS - PART I

(a) Runs 1 and 2 - in these two runs, aluminium inserts of two sizes were put in the one groove configuration of Figure 1-5. In run 1, the aluminium insert is 3mm by 4mm, that is, $a = b = 1$mm. In run 2, it is 4.99mm by 4mm, that is, $a = 0.005$mm and $b = 1$mm.

In each run, the linear dimensions used are:

$u = 3$mm

$t = 8$mm

$v = 19$mm

$m = n = 5$mm

The grid used in each run has the same number of nodal points in the x-direction, that is, $M = 20$, and those in the y-direction, that is, $N = 11$ (see Appendix). The distance between any two nodal points both in the x and y directions is 1mm. The assumed thermal conductivities are:

for aluminium, $k = 200$ W/M^{o}C

araldite, $k = 0.7$ W/M^{o}C

specimen, $k = 1$ W/M^{o}C

Run 1 simulates the case where araldite is present on the sides of the groove in bulk, and the aluminium insert

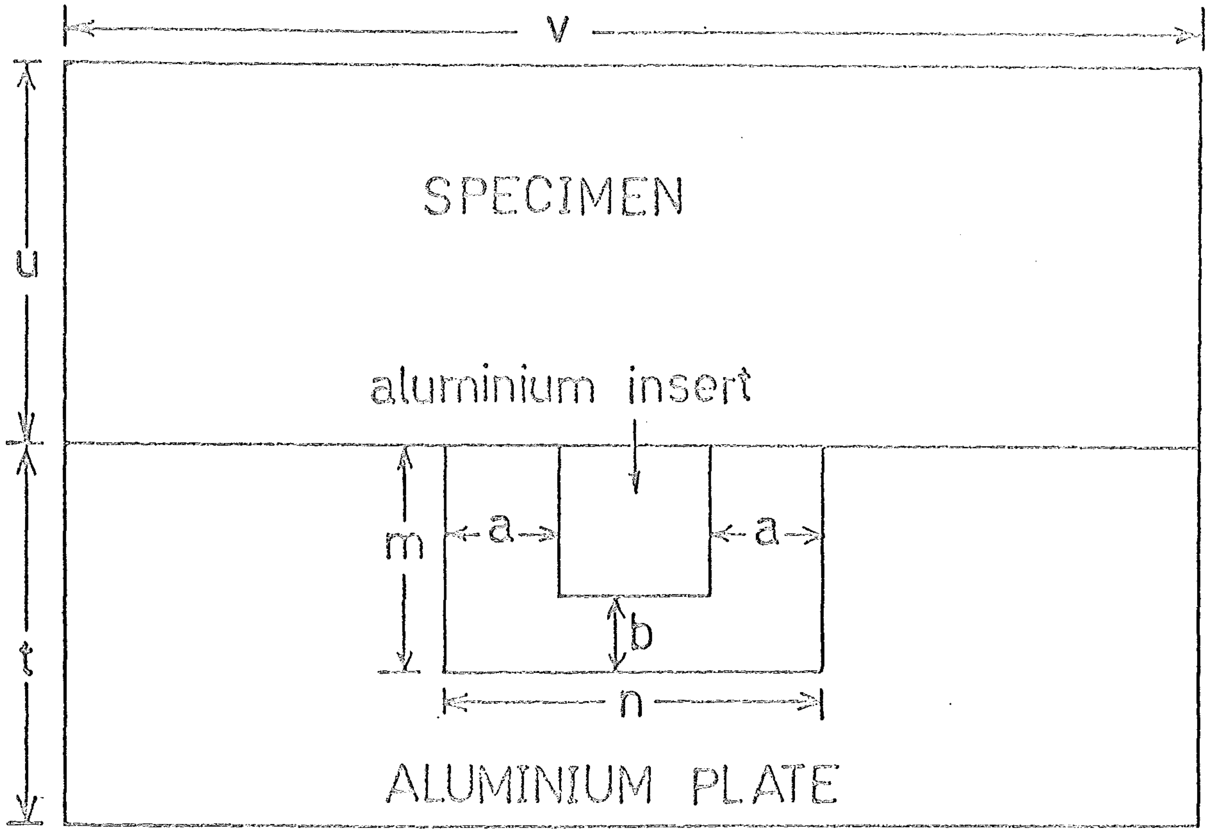


FIGURE 1-5 SKETCH OF THE PHYSICAL CONFIGURATION USED IN RUNS 1 and 2

does not fit tightly in the thermocouple groove. The 1mm gap at the bottom of the groove ('b'), is large enough to accommodate the 36 gauge thermocouple wires.

Run 2 simulates the case where the aluminium insert is machined to close tolerances so that it fits tightly in the thermocouple groove, leaving very little room (0.005mm) for any araldite to get caught between the insert and the aluminium plate. Again, enough room is left at the bottom of the cavity to accommodate the thermocouple wires.

(b) Runs 3 and 4 - these two runs were used to show the differences between the two possible boundary conditions. Run 3, like all the other simulation runs, uses zero heat flux boundary conditions at the edges, while run 4 uses constant temperature conditions at the edges (assumes uniform heat flux). The grid used is exactly the same as that used for runs 1 and 2, that is, M = 20 and N = 11. The thermocouple groove used in each run is a 2.38mm square groove with no aluminium insert. The groove is full of araldite of assumed thermal conductivity 0.167 W/M^{o}C for run 3 and 0.282 W/M^{o}C for run 4. The thermal conductivity of the specimen is taken as 0.167 W/M^{o}C in both runs, and that of aluminium as 238.4 W/M^{o}C. The linear dimensions used as referred to in Figure 1-3A are:

u = 1.428mm

t = 3.808mm

v = 9.044mm

m = n = 2.38mm

General remarks about simulation runs 5 to 10:

(i) Boundary conditions - for all runs, the hot boundary temperature was taken as 45.14°C and the cold boundary as 43°C. Zero heat flux boundary conditions were taken for the remaining two boundaries.

(ii) Thermal conductivities - the thermal conductivity of aluminium at the mean temperature was taken as 238.4 W/M°C, that of araldite was taken as 0.282 W/M°C and that of the specimen as 0.167 W/M°C. See the Appendix for the verifications of these values.

(iii) Program constants - the overrelaxation factor used in all runs was 1.26. All the temperatures were relaxed to within 0.005°C.

(c) Runs 5 and 6 - for run 5, the one groove configuration of Figure 1-3A was used. The thermocouple groove considered in this run is 2.38mm square. In run 6, there is no groove, that is, the place where the groove would have been is completely filled up by aluminium, corresponding to Figure 1-3C. Run 6 results gave the ideal complement to the results of run 5. The latter shows the effects of having a thermocouple groove, while the former shows the ideal case where the groove does not exist.

The grids used for both runs had M = 20 and N = 26. The dimensions used are:

m = 2.38mm

v = 9.044mm

t = 6.188mm (this corresponds approximately to the thickness of the aluminium plates used in the experiment)

u = 6.188mm (this corresponds approximately to the 1/4" PMMA specimens used in the experiment)

(d) Runs 7 and 8 - as one thermocouple groove was used in both these runs, Figure 1-3A applies. For run 7, the groove depth is taken to be twice the actual experiment groove depth, that is, m = 4.76mm, while the breadth of the groove is halved, that is, n = 1.19mm. This run was used to simulate a deep narrow thermocouple groove.

For run 8, however, the depth of the groove is kept at 2.38mm (experimental value), but the breadth is halved, that is n = 1.19mm.

For both runs 7 and 8, the grid used had M = 20 and N = 26. The other linear dimensions are:

t = u = 6.188mm

v = 4.522mm

Using runs 5, 6, 7, and 8, the effects of one groove of various dimensions on the surface temperatures were deduced. The effects of having three thermocouple grooves in the aluminium plates are now investigated.

(e) Runs 9 and 10 - run 9 simulates the experimental set-up exactly. Three grooves are considered in the simulation, hence Figure 1-3B is applicable. The linear dimensions used are exactly those mentioned in Chapter 2. They are summarised as follows:

n = m = 2.38mm

t = 6.35mm (¼")

u = 6.35mm

p = s = 125.4mm

r = q = 71.44mm

v = 400.82mm

Run 10 is the ideal experimental set-up with no thermocouple grooves, so that is provides the ideal results for complementing the actual results of run 9. The linear dimensions are exactly the same as those for run 9, except that m and n are not applicable of course, Figure 1-3C.

The grids used for both runs are with M = 32 and N = 13. (See the Appendix for conductance evaluation details for regions with thermocouple grooves in them (run 16)).

Table 1-1 summarises the surface temperature computer simulation runs numbered 1 to 10. In the table, all the linear dimensions are in millimeters and the symbols used are referred to Figure 1-3.

SIMULATION RUNS - PART II

As previously mentioned, computer runs numbered 11 to 16 constitute this part of the simulation. For all these runs, the following conditions are used:

(i) Boundary conditions - the hot boundary temperature was taken as 45.14^{O}C, and the cold boundary as 43.0^{O}C. Zero heat flux boundary conditions were used for the remaining two other boundaries.

(ii) Thermal conductivities - the thermal conductivity of aluminium at the mean temperature was taken as 238.4 W/M^{O}C, that of araldite as 0.282 W/M^{O}C, and that of the specimen (perspex) as 0.167 W/M^{O}C.

(iii) Program constants - the overrelaxation factor was 1.26 and all the temperatures were relaxed to within 0.005^{O}C.

TABLE 1-1

Qualitative Results of the Surface Temperature Simulation Runs 1 to 10

Simulation Run Number	Number of Grooves	Groove Dimensions in mm		Linear Dimensions of the Physical Layout in mm Figure 1-3			Grid Size		Boundary Conditions in °C		Thermal Conductivities in W/M°C			General Comments
		m	n	t	u	v	M	N	Th	Tc	aluminium	araldite	specimen	
1	1	5	5	8	3	19	20	11	100°C	20°C	200	0.7	1.0	3mm x 4mm aluminium insert put in groove
2	1	5	5	8	3	19	20	11	100°C	20°C	200	0.7	1.00	4.99mm x 4mm aluminium insert put in the groove
3	1	2.38	2.38	3.808	1.428	9.044	20	11	45.14	43.68	238.4	0.167	0.167	
4	1	2.38	2.38	3.808	1.428	9.044	20	11	45.14	43.68	238.4	0.282	0.167	constant temperature boundary conditions
5	1	2.38	2.38	6.188	6.188	9.044	20	26	45.14	43.00	238.4	0.282	0.167	this run simulates the experiments approximately
6	no groove is present, solid aluminium covers where the groove should have been			6.188	6.188	9.044	20	26	45.14	43.00	238.4	0.282	0.167	this run gives the ideal temperature profile for run 5
7	1	4.76	1.19	6.188	6.188	4.522	20	26	45.14	43.00	238.4	0.282	0.167	a deep narrow groove is simulated
8	1	2.38	1.19	6.188	6.188	4.522	20	26	45.14	43.00	238.4	0.282	0.167	a narrow groove is simulated
9	3	2.38	2.38	6.35	6.35	400.82	32	13	45.14	43.0	238.4	0.282	0.167	16 nodal points put in each groove
10	no grooves are present, solid aluminium covers where the grooves should have been			6.35	6.35	400.82	32	13	45.14	43.0	238.4	0.282	0.167	no grooves are present - this gives the ideal temperature profile for run 9

(iv) Linear dimensions - the linear dimensions as referred to Figure 1-3 are as follows:

$t = u = 6.35$mm

$p = s = 125.4$mm

$r = q = 71.44$mm

$v = 400.82$mm

The number of grooves and the groove dimensions varied with each run, consequently the values of q and r for example were applicable only when three grooves were considered. The grid used for all the runs had $M = 32$ and $N = 17$.

(a) Run 11 - in this run, one groove 2.38mm x 2.38mm is considered with a 1.5875mm x 1.5875mm (1/16" square) aluminium insert in it. The dimensions in the groove region are thus:

$m = n = 2.38$mm

$a = 0.39625$mm (1/64")

$b = 0.7925$mm (1/32")

This run simulates a possible configuration of the apparatus with very small gaps on the sides of the groove and a gap at the bottom of the groove large enough to fit the thermocouple wires.

(b) Run 12 - in this run, one groove 2.38mm x 2.38mm is considered. This simulates another possible experimental set-up in which only one groove rather than three could have been used.

(c) Run 13 - three grooves are considered of shallow depth but same width (or breadth) as used in the experiment. The linear dimensions of the grooves being:

$m = 0.952$mm

$n = 2.38$mm

(d) Run 14 - one deep groove is considered in this configuration, the width is exactly the same as used in the experimental set-up. The linear dimensions of the groove are:

$m = 5.026$mm

$n = 2.38$mm

(e) Run 15 - in this run, the ideal temperature profile for all the other simulation runs of Part II is presented. No grooves are present in this simulation, only solid aluminium. Since the experimental set-up linear dimensions are used, this run represents the ideal temperature profile for the experimental set-up used in this thesis.

(f) Run 16 - this run represents the experimental set-up as it is in this work (Chapter 2). Three grooves of 2.38mm x 2.38mm linear dimensions are considered.

Table 1-2 presents a summary of all the simulation runs of Part II, that is, runs numbered from 11 to 16. As all the linear dimensions, grid sizes, boundary conditions, and thermal conductivities are the same for each run, only the groove characteristics are presented in the table shown.

1.6.3.4.7 Quantitative computed results of the surface temperature simulation runs

The surface temperature results are presented in tabular form (Tables 1-3 to 1-8), with the positions of the thermocouple grooves as indicated in the tables of results. As the simulations of runs 11 to 16 approximated the experimental conditions, only this range of results is presented in this section. The results of simulation runs 1 to 10 are presented in the Appendix, where the computer listings with the various

TABLE 1-2

Qualitative Results of the Surface Temperature Simulation Runs Numbers 11 to 16

Simulation Run Number	Number of Grooves	Groove Dimensions in mm		Comments
		m	n	
11	1	2.38	2.38	1/16" x 1/16" aluminium insert in groove
12	1	2.38	2.38	Simulating one groove instead of three
13	3	0.952	2.38	Simulating three shallow grooves
14	1	5.026	2.38	Simulating one deep groove
15	No grooves are present, solid aluminium covers where the grooves should have been			Ideal temperature profiles
16	3	2.38	2.38	Actual experimental set up used in this work

TABLE 1-3

Temperature profile of simulation run 11 showing the 1 groove configuration with a 1.6mm x 1.6mm aluminium insert in the groove

514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	467	454	454	467	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	405	406	406	406	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	513	406	406	406	406	513	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	513	406	406	406	406	513	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	513	406	406	406	406	513	514	514	514	514	514	514	514	514	514	514	514	514	514
500	500	500	500	500	500	500	500	500	500	500	500	500	495	444	429	429	444	495	500	500	500	500	500	500	500	500	500	500	500	500	500
485	485	485	485	485	485	485	485	485	485	485	485	485	479	453	440	440	453	479	485	485	485	485	485	485	485	485	485	485	485	485	485
471	471	471	471	471	471	471	471	471	471	471	471	471	464	450	442	442	450	464	471	471	471	471	471	471	471	471	471	471	471	471	471
457	457	457	457	457	457	457	457	457	457	457	457	457	452	442	437	437	442	450	457	457	457	457	457	457	457	457	457	457	457	457	457
443	443	443	443	443	443	443	443	443	443	443	443	443	436	432	429	429	432	436	443	443	443	443	443	443	443	443	443	443	443	443	443
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386	386	386	386	386	386	386	386	386	386	386	386	385	381	381	381	381	381	382	385	386	386	386	386	386	386	386	386	386	386	386	386
343	343	343	343	343	343	343	343	343	343	343	343	343	341	341	341	341	341	341	343	343	343	343	343	343	343	343	343	343	343	343	343
300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300

TABLE 1-4

Temperature profile of simulation run 12

showing the 1 groove configuration

514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
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514	514	514	514	514	514	514	514	514	514	514	514	514	514	513	512	512	513	514	514	514	514	514	514	514	514	514	514	514	514	514	514
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471	471	471	471	471	471	471	471	471	471	471	471	471	471	469	469	469	469	471	471	471	471	471	471	471	471	471	471	471	471	471	471
457	457	457	457	457	457	457	457	457	457	457	457	457	456	456	455	455	456	456	457	457	457	457	457	457	457	457	457	457	457	457	457
443	443	443	443	443	443	443	443	443	443	443	443	443	442	442	441	441	442	442	443	443	443	443	443	443	443	443	443	443	443	443	443
428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428
386	386	386	386	386	386	386	386	386	386	386	386	386	385	385	385	385	385	385	386	386	386	386	386	386	386	386	386	386	386	386	386
343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343
300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300

TABLE 3-5

Temperature profile of simulation run 13

showing the 3 shallow groove configuration

514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	511	510	510	511	514	514	514	514	514	511	510	510	511	514	514	514	514	514	511	510	510	511	514	514	514	514	514
514	514	514	514	514	507	505	505	507	514	514	514	514	514	507	505	505	507	514	514	514	514	514	507	505	505	507	514	514	514	514	514
500	500	500	500	499	496	494	494	496	499	500	500	500	499	496	494	494	496	499	500	500	500	499	496	494	494	496	499	500	500	500	500
485	485	485	485	485	483	482	482	483	485	485	485	485	485	483	482	482	483	485	485	485	485	485	483	482	482	483	485	485	485	485	485
471	471	471	471	471	470	469	469	470	471	471	471	471	471	470	469	469	470	471	471	471	471	471	470	469	469	470	471	471	471	471	471
457	457	457	457	457	456	455	455	456	456	457	457	457	456	456	455	455	456	456	457	457	457	456	456	455	455	456	457	457	457	457	457
443	443	443	443	442	442	442	442	442	442	443	443	443	442	442	442	442	442	442	443	443	443	442	442	442	442	442	442	443	443	443	443
428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428
386	386	386	386	385	385	385	385	385	385	386	386	386	385	385	385	385	385	385	386	386	386	385	385	385	385	385	385	386	386	386	386
343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343
300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300

TABLE 1-6

Temperature profile of simulation run 14

showing the 1 deep groove configuration

514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	513	513	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	513	513	513	513	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	513	512	512	513	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	512	511	511	512	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	510	508	508	510	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	506	503	503	506	514	514	514	514	514	514	514	514	514	514	514	514	514	514
500	500	500	500	500	500	500	500	500	500	500	500	500	499	495	493	493	455	499	500	500	500	500	500	500	500	500	500	500	500	500	500
485	485	485	485	485	485	485	485	485	485	485	485	485	485	483	481	481	483	485	485	485	485	485	485	485	485	485	485	485	485	485	485
471	471	471	471	471	471	471	471	471	471	471	471	471	471	469	469	469	469	471	471	471	471	471	471	471	471	471	471	471	471	471	471
457	457	457	457	457	457	457	457	457	457	457	457	457	456	456	455	455	456	456	457	457	457	457	457	457	457	457	457	457	457	457	457
443	443	443	443	443	443	443	443	443	443	443	443	443	442	442	441	441	442	442	443	443	443	443	443	443	443	443	443	443	443	443	443
428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428
386	386	386	386	386	386	386	386	386	386	386	386	386	385	385	385	385	385	385	386	386	386	386	386	386	386	386	386	386	386	386	386
343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343
300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300

TABLE 1-7

Temperature profile of simulation run 15

showing the ideal temperature profile of

the no groove configuration

514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485	485
471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471
457	457	457	457	457	457	457	457	457	457	457	457	457	457	457	457	457	457	457	457	457	457	457	457	457	457	457	457	457	457	457	457
443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443	443
428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428
386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386
343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343
300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300

TABLE 1-8

Temperature profile of simulation run 16

showing the 3 groove configuration

as used in the experimental set up

514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	513	513	513	513	514	514	514	514	514	513	513	513	513	514	514	514	514	514	513	513	513	513	514	514	514	514	514
514	514	514	514	514	513	512	512	513	514	514	514	514	514	513	512	512	513	514	514	514	514	514	513	512	512	513	514	514	514	514	514
514	514	514	514	514	512	511	511	512	514	514	514	514	514	512	511	511	512	514	514	514	514	514	512	511	511	512	514	514	514	514	514
514	514	514	514	514	510	508	508	510	514	514	514	514	514	510	508	508	510	514	514	514	514	514	510	508	508	510	514	514	514	514	514
514	514	514	514	514	506	503	503	506	514	514	514	514	514	506	503	503	506	514	514	514	514	514	506	503	503	506	514	514	514	514	514
500	500	500	500	499	455	493	493	495	499	500	500	500	499	455	493	493	495	499	500	500	500	499	495	493	493	495	499	500	500	500	500
485	485	485	485	485	483	481	481	483	485	485	485	485	485	483	481	481	483	485	485	485	485	485	483	481	481	483	485	485	495	485	485
471	471	471	471	471	469	469	469	469	471	471	471	471	471	469	469	469	469	471	471	471	471	471	469	469	469	469	471	471	471	471	471
457	457	457	457	457	455	455	455	456	456	457	457	457	456	456	455	455	456	456	457	457	457	456	456	455	455	456	457	457	457	457	457
443	443	443	443	442	442	442	442	442	442	443	443	443	442	442	441	441	442	442	443	443	443	442	442	442	442	442	442	443	443	443	443
428	428	428	428	428	428	428	428	428	428	428	428	426	428	428	428	428	428	428	428	428	428	428	426	428	428	428	428	428	428	428	428
386	386	386	386	385	385	385	385	385	385	386	386	386	385	385	385	385	385	385	386	386	386	385	385	385	385	385	385	386	386	386	386
343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343
300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300

problem data used, for example, conductances and heat flows are also presented.

1.6.3.4.8 Discussion of the surface temperature results

In this part of the thesis, the effects of having thermocouple grooves in the aluminium plates are discussed. The optimal number and dimensions of the grooves are also discussed. However, not discussed are the effects of actually having the thermocouple wires in the grooves. That is, although the dimensions of the thermocouple wires are taken into consideration in the dimensioning of the simulation grooves, their actual physical presence is ignored. The conduction errors, and the thermal conductivities due to the thermocouple wires are ignored in the simulations.

As expected (see the discussions of prior work done on surface temperature measurement), if a thermocouple groove is introduced, the temperature profile of the surface is distorted. Table 1-4 (showing the results of a one-groove configuration) shows this clearly. Without the thermocouple groove, all the temperatures in the aluminium block are equal to 45.14^{O}C (run 15), however, once a thermocouple groove is introduced, temperature gradients result. This phenomena is also shown clearly by run 16 where three grooves are present (runs 5 and 6 in the Appendix show this effect also). In the grooves, the temperature at the specimen-araldite interface is 45.03^{O}C, and it increases towards the aluminium surface temperature of 45.14^{O}C at the bottom of the groove. This comment applies to all other runs with grooves in them, the exception being run 7. Since the introduction of a thermocouple groove (or grooves) causes very significant temperature and heat flux profile distortions (all runs except 6, 10 and 15), the exact positioning of a thermocouple in a groove is important in ascertaining the true surface temperature. For example, if in run 12 (driving force dT = 2.14°C) a thermocouple measuring junction was positioned 0.952mm from the side of the groove and at a depth of 0.952mm from the bottom of the groove, the temperature it would indicate, assuming no conduction and other thermocouple wire errors (as discussed in section 1.6.3.2), would be 45.12°C. The true (or correct) surface temperature being 45.14°C (from runs 12 and 15). The true surface temperature being defined as the temperature of the surface when no thermocouple grooves are present (Figure 1-3C). For example, 45.14°C for run 15.

The introduction of an aluminium insert in the groove tends to smooth out the sharp temperature gradient at the araldite-specimen interface. Runs 11 and 12 show this effect clearly. In run 12, where the insert is not present, the specimen does not have a large influence on the temperature gradient in the groove. However, with the aluminium insert in the groove (run 11), the specimen seems to have a very significant effect on the temperature distribution in the groove. In fact, in run 11, the temperature at 0.476mm from the bottom of the groove is 44.54°C which is significantly different from the correct aluminium surface temperature of 45.14°C. While the presence of an aluminium insert in the groove helps to smooth out the sharp temperature gradients at the araldite-specimen interface, it does not help to bring the thermocouple wires in the groove any closer to monitoring the correct surface temperature. Runs 1 and 2 also verify this fact. In run 1, for example, the true surface temperature is between 98.85°C and 98.98°C, while the thermocouple wires placed at the bottom of the groove would indicate a reading between 91.2°C and 99.79°C. As a consequence, in the experimental set-up (Chapter 2) used in this work, no aluminium inserts were put in the thermocouple grooves.

The temperature profile in the thermocouple groove obtained when using the one groove configuration (Figure 1-3A) is exactly the same as that obtained when using the three groove configuration (Figure 1-3B). The araldite-specimen interfacial temperatures are the same in both cases too. Runs 12 and 16 verify these statements. For instance, in run 12, the temperature at 0.476mm from the bottom of the groove is 45.13°C. This is exactly the same temperature indicated in the three groove configuration (run 16) at the same groove position. In the experimental set-up, the three groove configuration is thus adopted (justifications for this choice of configuration is presented in the next section).

Three shallow thermocouple grooves (run 13), do not give very good estimates of the true surface temperatures. They give far worse estimates than run 16 (that is, the adopted configuration for the experimental set-up). In run 13, the temperature indicated at a depth of 0.476mm from the bottom of the shallow thermocouple groove is 45.10°C. This is as compared to 45.13°C for run 16, and 45.14°C for the true surface temperature, run 15.

One deep groove (simulation) gives the desired result, subject to the measuring junction being placed less than 0.476mm from the bottom of the groove. At this distance from the bottom of the groove, the temperature is equal to the surface temperature. From run 14, at a distance of 0.476mm from the bottom of the groove, the indicated temperature is 45.14°C which is the correct surface temperature. Run 7 shows that for a deep groove, the other linear dimensions, that is, the width of the solid material on either side of the groove needs to be large before the surface temperature can be attained at the bottom of the groove. In run 7, a deep narrow groove with the other linear dimensions small is considered. The true surface temperature is close to 44.13°C, but the indicated temperature at the bottom of the groove is close to 44.75°C.

Reliability of the Solutions

Numerous simulation runs were devised to verify the validity and accuracy of the computer solutions. Apart from the simulation runs already discussed above (runs 1 to 16) in which different problems were solved, many other runs were performed with the following conditions:

(1) different initial and boundary conditions

(2) different tolerances of the temperature accuracies, that is, the tolerances were sometimes put as low as 10^{-6}

(3) different grid sizes (in the runs 1 to 16, different sizes were used)

(4) different relaxation parameters - the problem was solved both by overrelaxation, that is, W greater than 1 and less than 2; and by underrelaxation, W was put at 0.8

In all cases, the computed temperatures had converged and the heat balances satisfied. Since the computer program converged under all these trying conditions, the program was verified.

1.6.3.4.9 Optimal approximations

Although one deep thermocouple groove (run 14) gave a better approximation of the true surface temperature (see below) in the experimental set-up (Chapter 2), three grooves were used (exactly as set out in run 16). The three groove configuration was chosen for three primary reasons.

(1) More thermocouple wires could be put in the three grooves (9 thermocouples), and as the grooves were spread over a large area of the aluminium plates, they gave a better estimate of the temperature of the aluminium plate. By having more thermocouple wires, inherent experimental errors (for example, the uncertainty in the exact positions of the measuring junctions in the grooves) were averaged (smoothed) out.

(2) The experiments undertaken using the guarded hot plate apparatus were based on the assumption that uni-directional heat flow existed (section 1.6.1.6). To verify this assumption, the temperatures at various positions of the aluminium plates were required. The three groove configuration fulfilled this requirement.

(3) The temperatures indicated in the three groove configuration were not far removed from the true surface temperatures (and also those indicated by the one groove configuration) bearing in mind that thermocouple circuits

at their best performances give temperatures accurate to within $\pm$ 0.02^{o}C. This figure was also the indicated maximum deviation from the true surface temperature in the groove (discussed above - runs 11 to 16) at temperatures between 45.14^{o}C and 43.0^{o}C. (These are typical experimental temperatures for ¼" perspex as the specimen - experiments series A.)

1.6.3.5 Thermal Contact Resistance

At the interface between two materials held together in unbonded contact, there is a resistance to heat flow due to imperfect contact. This thermal resistance between the two surfaces is called the contact resistance. In the experimental set-up used in this work (Chapter 2), the specimen (usually perspex) is in contact with the hot and cold aluminium plates of the hot guarded plate apparatus. As a result, there are contact resistances between the specimen and the aluminium plates. Estimates of the magnitudes and hence importance of these resistances were required.

1.6.3.5.1 Prior work on thermal contact resistance

Although the thermal conduction contribution to heat transfer at contacts has been recognised for a long time, the amount of scientific and engineering work performed to understand this problem has been fairly limited.

Cetinkale and Fishenden (130) are among some of the earliest workers in this field. They described measurements of the thermal contact conductance for steel, brass and aluminium surfaces ground to various degrees of roughness, and with air, spindle oil, or glycerol between the contacting surfaces. They measured the contact conductances for a range of contact pressures. Reasonable agreement was also obtained between the experimental results and an approximate analytical solution for which the surface roughness, the thermal conductivities of the metal and fluid, the applied pressure, the hardness of the softer metal, and the mean contact temperature must be known.

Other investigators worthy of note who have dealt with this subject in detail include: Fried (131), Fenech and Rohsenow (132) and Mikic (133,134). A thorough review of the subject of interfacial resistance is dealt with more recently by Fried E. in Tye's book (135).

1.6.3.5.2 Method of estimating the thermal contact resistance

Heat transfer through an interface takes place by combined mechanisms of conduction across true contact points, conduction across entrapped interstitial fluid, and radiation across interstitial gaps. Resulting overall conductance of the joint is therefore a function of the materials in contact (conductivity, surface finish, flatness, and hardness), the contact pressure, the mean temperature and heat flux across joint, the nature of interstitial fluid (liquid, gas, vacuum), and the presence of oxide films.

Various publications (51,132) have presented graphs of thermal interface conductance data for various materials under different conditions. None of the conditions or the data presented simulated the experimental conditions used in this work. As a result, using the guarded hot plate apparatus with perspex as the specimens, experiments were performed to try to determine the surface contact conductance in this work. The details and results of these runs will be presented in Chapters 3 and 4. * However, briefly the runs consisted of measuring the thermal conductivities of perspex pieces with no lubrication on them, and then lubricating them with a light oil on both faces and measuring the thermal conductivities again. The light oil film provided good thermal contact between the specimens and the aluminium plates. The differences in thermal conductivities between the two runs should have given estimates of the effects of surface conductances. As will be seen in Chapter 4, no significant difference between the runs resulted. Consequently, no estimate of the surface contact resistance was obtained.

1.6.3.6 Concluding Remarks on Surface Temperature Measurement

Since the thermal contact resistance is small and can be neglected, the only source of error in determining the temperatures of the specimens is in the measurement of surface temperature. By careful design, the thermocouple measuring junctions can be made to monitor the surface

* In Laboratory experiments in the Chemical Engineering Department, University of Canterbury involved with measuring surface temperatures of apparatus using thermocouples attached to copper contact shoes, it had been found that silicone grease between the copper shoe and the surface being measured significantly increased the accuracy of the measurements.

temperature to within $\pm$ 0.02^{o}C of the true value. From the numerical simulation runs, the optimal number of thermocouple grooves was found to be three, and the best location of the measuring junctions was found to be at a distance of not more than 0.476mm from the bottom of the 2.38mm square groove.

1.7 CONCLUSION

To analyse the cavity problem fully, separate experimental measurements of gas conduction, solid conduction and radiation heat flows are required. As research into the cavity problem continued, it became clear that a complete solution to the problem would take years to complete. As a result, the work outlined in this thesis was directed at providing the theoretical and experimental basis for future work.

The experimental apparatus was designed, built and tested. The discrepancies between the experimental and the theoretical results varied between 2 and 26%. The experimental error was 12%.

CHAPTER 2

EQUIPMENT

CHAPTER 2

EQUIPMENT

2.1 THE APPARATUS AND EXPERIMENTAL TECHNIQUE

In the tests it was necessary to generate, control, and measure the following systems: thermal conductivity of specimen material, heat flux, isothermal faces, cell orientation (shape and size as well), and material (type and thickness).

2.2 EQUIPMENT DESIGN CONSIDERATIONS

2.2.1 GENERAL REMARKS

(1) Maximum and minimum working temperatures - two different types of guarded hot plate apparatus are described in the literature (6). The low temperature guarded hot plate, which has metal surface plates and a definite guard gap, is generally used for measurements over the approximate temperature range 90° to $600^{\circ}K$. The high temperature guarded hot plate, which may or may not have metal surface plates, and may or may not have a definite guard gap, is ordinarily used for measurements where the hot plate temperature is greater than $550^{\circ}K$ and less than $1350^{\circ}K$. In this work, the low temperature guarded hot plate apparatus was used since the materials available locally were of the building, refrigeration, and other constructional varieties (temperature range 200 to $400^{\circ}K$).

(2) As previously mentioned (Chapter 1), it is practically impossible to distinguish between the solid conduction contribution to the total heat transferred and

the thermal radiation contribution experimentally in the cavity problem. As such, the experiments had to be designed so that they could be performed in two parts. The first part of each experimental series of runs was concerned with measuring heat transfer rates in an opaque solid - where solid conduction is the only mechanism of heat transfer. The second part of the experiments also measured the rates of heat transfer for the same temperature differences as those used in the first part, the difference being that holes were drilled in the opaque solids to induce radiation and gaseous conduction. For different temperature differences, hole sizes, thicknesses of material and materials, different ratios of radiation to solid conduction were obtained. Hence the radiation and solid conduction contributions to the total heat transferred could be assessed.

As a result, the apparatus was designed so that:

(a) it could accommodate various sizes of materials (specimens)

(b) dismantling and assembling of the test stack could be done quickly and easily

2.2.2 DESIGN CONSIDERATIONS OF LOW TEMPERATURE GUARDED HOT PLATE

The general features of the metal surfaced guarded hot plate are shown schematically in Figure 2-4.

2.2.2.1 Design of the Plates

The materials of construction of the plates had to withstand the operating temperatures. As the maximum operating temperature is $600^{\circ}K$, most metals would suffice.

The plates had to be:

(a) of sufficient thickness such that warping would not result

(b) made of non-corroding metal of high thermal conductivity

(c) of constant surface properties - the emissivity of the plates had to be of constant value during the experimental runs

(d) rigid enough to retain their linear dimensions and flatness during all operating conditions

Other design considerations for the plates include:

(i) methods of attaching the heating elements to the hot plates so that the electrical power dissipated could be divided evenly between the two specimens

(ii) adequate cooling for the heat dissipated by the heating elements

(iii) methods of attaching thermocouple wires to both the hot and cold plates

2.2.2.2 Design of the Heating Circuit

The various components used in the heating circuit had to:

(a) withstand the operating temperatures

(b) provide a steady heat input into the hot plates; this electrical supply is required not to interfere with the operations of the thermocouple wires

(c) provide enough electrical power to heat both the central metering section and the guard ring areas of the plates

Methods of measuring the electrical power had also to be considered.

2.2.2.3 Surface Temperature Measuring

The analyses of surface temperature measurement errors in Chapter 1 have shown some procedures that should be followed in order to obtain better estimates of surface temperatures. These procedures and the specifications of surface temperature measuring given in the A.S.T.M. Standard C177-71 (5) are considered as the design requirements in ascertaining the correct surface temperature measurements in the experiment. They are summarised as follows:

(1) Use the smallest possible installation (thermocouple wires and grooves) to avoid perturbation errors.

(2) Bring the thermocouple wires away from the junction along an isotherm for at least 20 wire diameters to reduce conduction errors. The use of thin thermocouple wires or thermocouple wires with low thermal conductivity will also reduce this error.

(3) Locate the measuring junction, as mentioned in Chapter 1, at the optimal position.

(4) Design the installation so that it causes a minimum disturbance of change in the emissivity of the surface, to avoid changes in radiative heat transfer.

(5) Design the installation so that the total response is fast enough to cause negligible lag for the transients expected in service.

(6) Reduce the thermal resistance between the measuring junction and the surface to as low a value as possible.

Other design considerations of surface temperature measuring include: having enough thermocouple wires in the central section of the plates, and also having a means of finding the temperature differences between the central section and the guard ring areas.

2.2.2.4 Sample Requirements

The test sample should be composed of two similar pieces (specimens) of a requisite uniform thickness and cross-section. These pieces should be as flat as possible so that intimate contact between specimens and plates can be achieved. The physical properties of the specimens must be constant over the operating temperature range, for example, the moisture content should be constant, and so should the linear dimensions. The specimens should have a low thermal conductivity so that adequate temperature differences can be achieved. As holes will be drilled in the specimens, they need to be machineable.

These pieces (specimens) should be cut so that they represent areas equivalent to the central and guard sections respectively. This serves two purposes:

(1) The area, A, used in the calculation of the thermal conductivity (conductance) is clearly defined in terms of the side of the central piece rather than including an additional half the gap width.

(2) Radial conduction is reduced and a more uniform temperature distribution throughout the sample can be maintained.

2.2.2.5 Miscellaneous Design Requirements

- Provide means for (i) imposing a reproducible constant pressure of the plates against the specimens to promote good thermal contact. (ii) measuring the effective thicknesses and other linear dimensions of the specimens.

- Provide means of reducing heat losses from the outer edges of the guard section and the specimen.

- Provide a cabinet or enclosure to surround the guarded hot plate. This enclosure should maintain the desired interior air temperature and the dew point in order that condensation is prevented. It also must allow the heat generated in the enclosure to escape at a sufficient rate at the operating temperatures.

2.3 DESCRIPTION OF APPARATUS

The general layout of the installation is shown in Figures 2-1 and 2-2. Electrical energy is supplied into the guarded hot plate apparatus from the mains A.C. supply through an A.C. regulator and a D.C. regulator. This power input is measured using a digital voltmeter and a digital ammeter. Using the nine thermocouple wires on each face of the isothermal plates, the temperature of each plate is known by monitoring the thermocouple wire outputs using a Cambridge Laboratory precision potentiometer. The thermocouple measuring circuit is shown in detail in Figure 2-9. The environmental conditions are kept constant by immersing the guarded hot plate set in a stainless box in a well stirred water thermostatic bath kept at 31°C. The thermostatic bath is kept at this constant temperature by using cooling coils (from the main cold water supply), an immersion heater, and a bias heater connected to a temperature controller. Since the room in which the experiments were performed was air conditioned (room temperature was 22°C $\pm$ 3°C), all the thermocouple circuit junctions were assumed

FIGURE 2-1

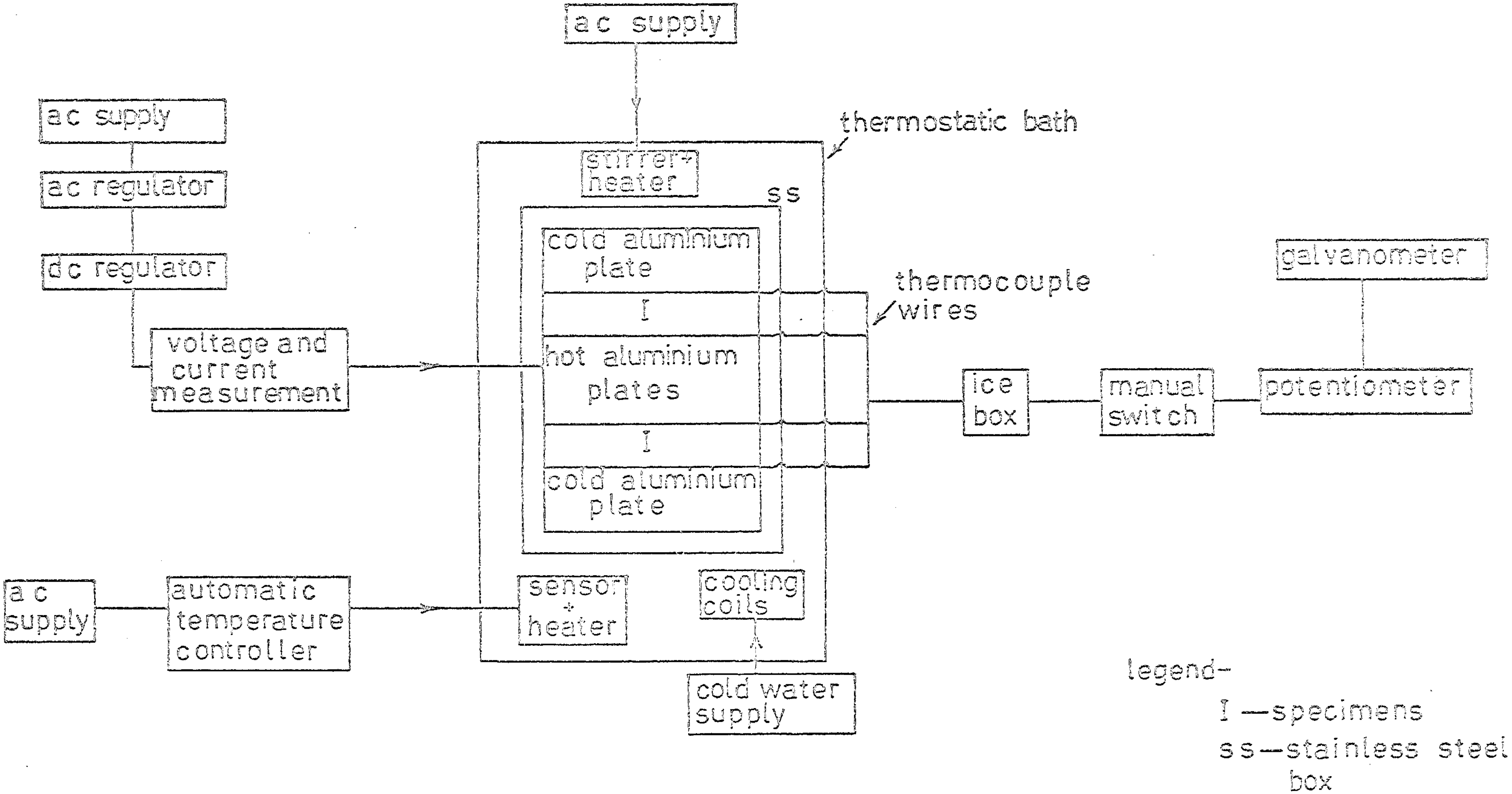


FIGURE 2-2 FLOW DIAGRAM OF THE INSTALLATION

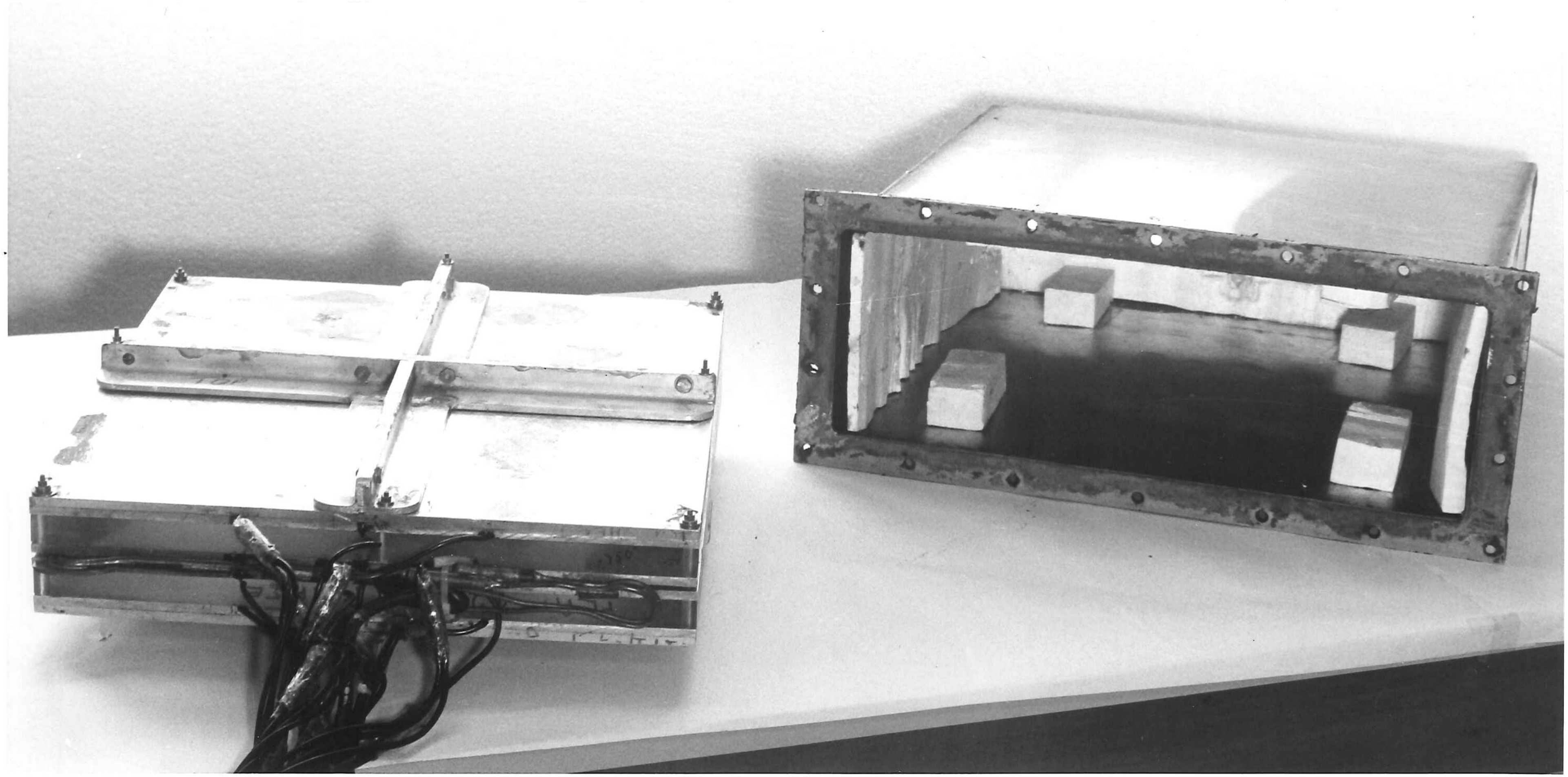
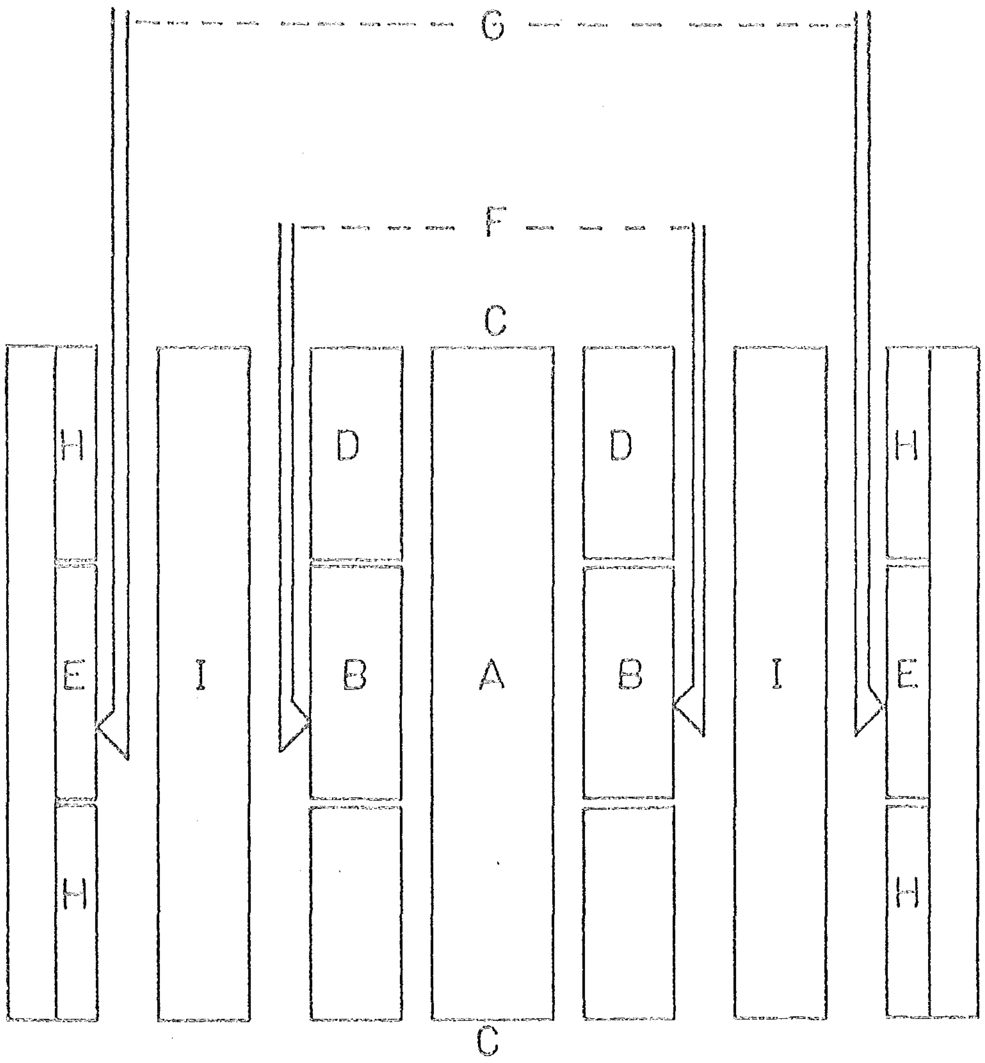


FIGURE 2-3



A- central heater core — the same coil is used to heat the metered section B and the guard section D

B- central surface plates-aluminium hot plates metered area

C- guard heater area of the main heater A

D- guard surface plates (aluminium hot plates)

E - cold aluminium plates

F- heating unit surface thermocouples

G- cooling unit surface thermocouples

H- guard area of the cold aluminium plates

I - test specimens

FIGURE 2-4 SCHEMATIC ASSEMBLY OF THE LOW TEMPERATURE GUARDED HOT PLATE

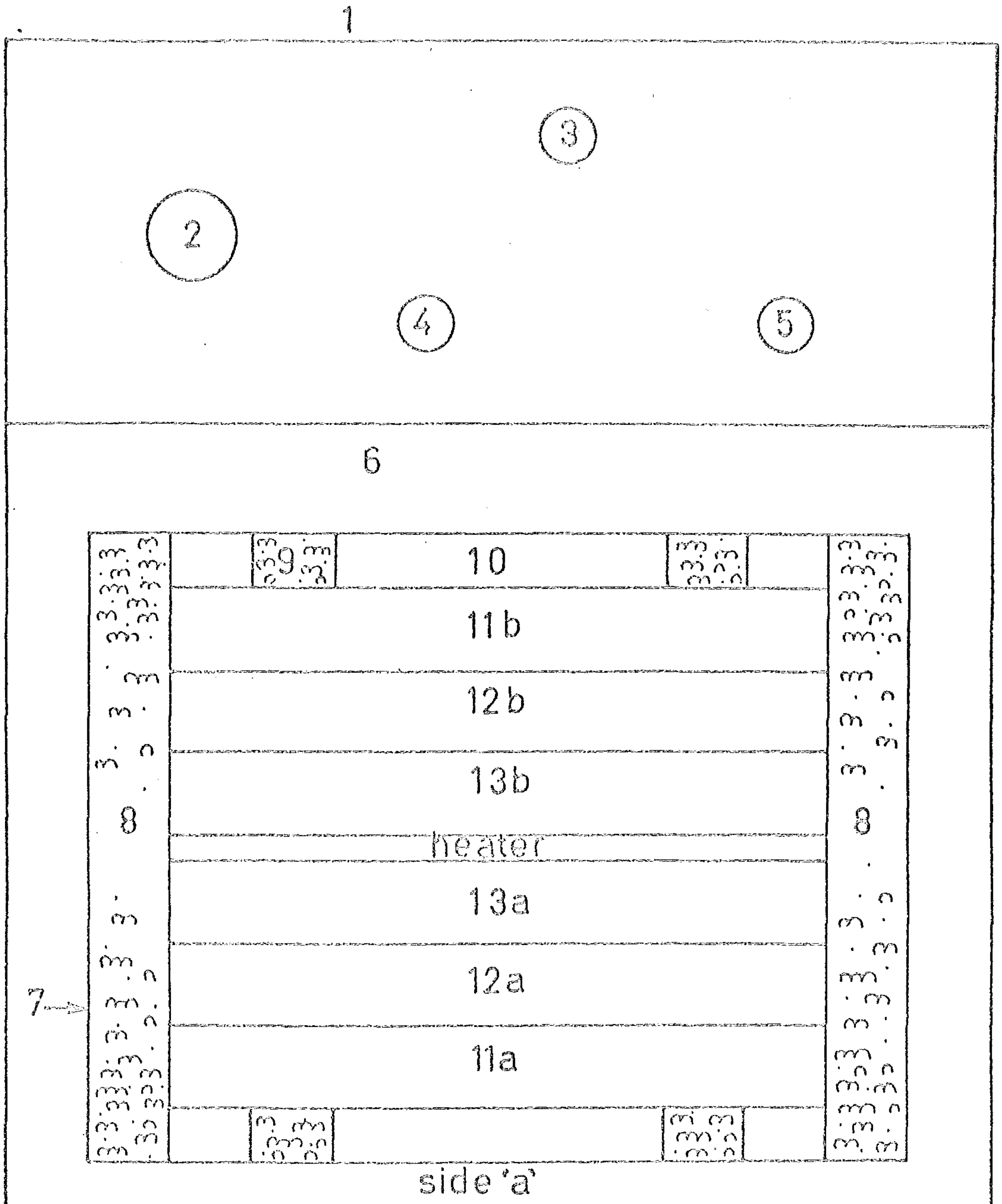


FIGURE 2-5 ARRANGEMENT OF THE GUARDED HOT PLATE STACK IN THE STAINLESS STEEL BOX IMMERSED IN THE BATH

LEGEND FOR FIGURE 2-5

1. Thermostatic water bath
2. Stirrer assembly
3. Controlled heater
4. Main water bath heater
5. Thermister probe connected to temperature controller
6. Water
7. Stainless steel box (enclosure) containing the guarded hot plate
8. Polystyrene edge insulation
9. Polystyrene studs
10. Air contained in the box
11. Cold aluminium plate
12. Test specimen
13. Hot aluminium plate

to be at the same temperature.

The individual equipment items are presented below.

2.3.1 LOW TEMPERATURE GUARDED HOT PLATE

The major part of the equipment used in this work consisted of the low temperature guarded hot plate apparatus. This apparatus was adapted from one designed by Gilbo (2) in 1957. It meets the requirements of the A.S.T.M. method C177. The guard heaters used to ensure uni-directional heat flow in the A.S.T.M. method are replaced by an envelope hot plate (Figure 2-4). Also the isothermal heat sink provided by a circulating liquid in the A.S.T.M. method is now provided by enclosing the outer faces of the conductivity cell in sheets of high conductivity material (aluminium) and placing the whole unit inside a stainless steel box, in a tank of coolant (Figure 2-5).

2.3.1.1 Hot Plate

The general features of the aluminium hot plate are shown in Figure 2-7. The aluminium plates are 398.5mm square, and are of thicknesses 6.35mm (¼") on either side of the 3.1mm diameter pyrotenax heating cable. The metered central section and the guard section are of almost equal area and are separated by a gap of 1.6mm (1/16"). The metered central section is 200mm square with a set of nine thermocouple wires (36 gauge copper-constantan) in accurately machined (150mm x 2.38mm x 2.38mm) grooves. The positions of the thermocouple wires in the grooves are shown in Figure 2-7. The measuring junction of each thermocouple pair was placed as close as possible to the bottom of the groove. Both

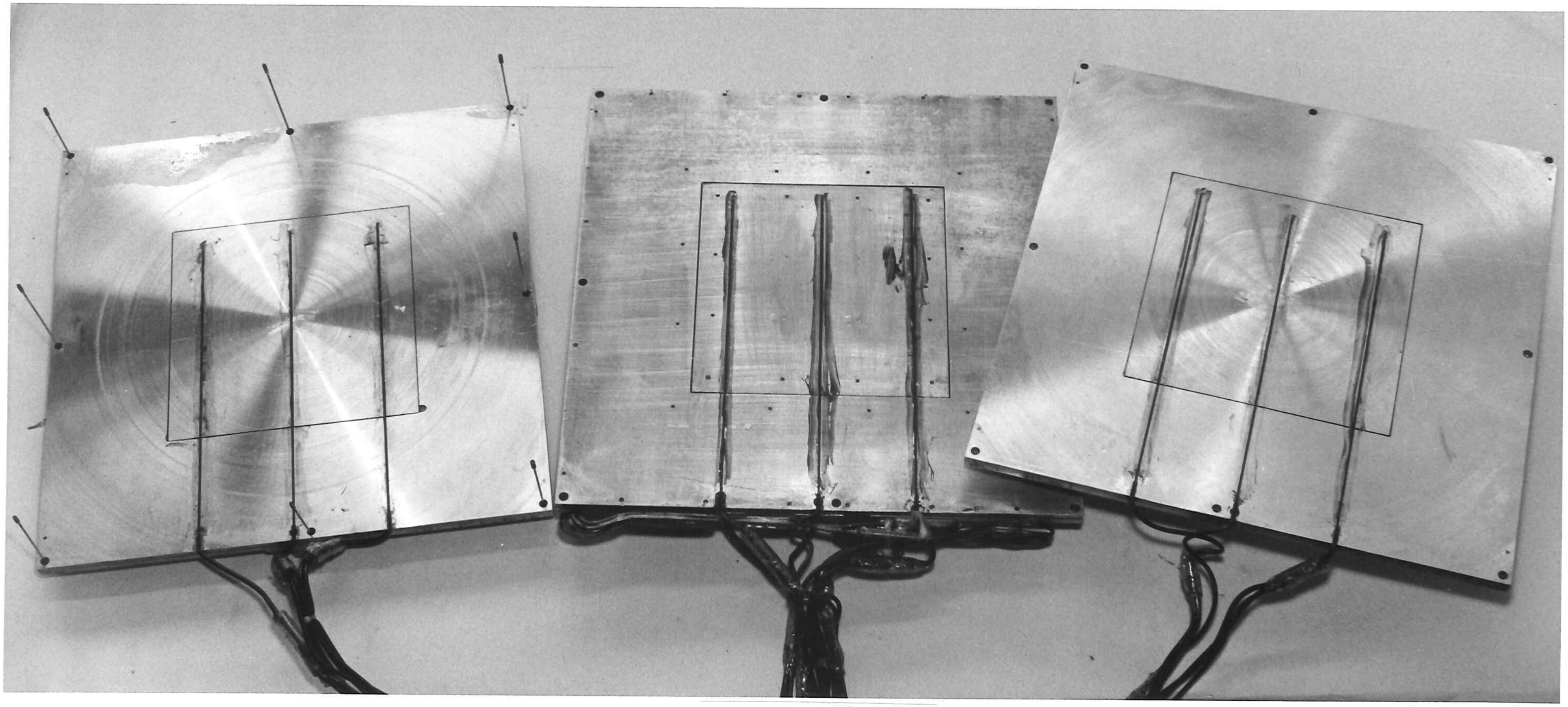
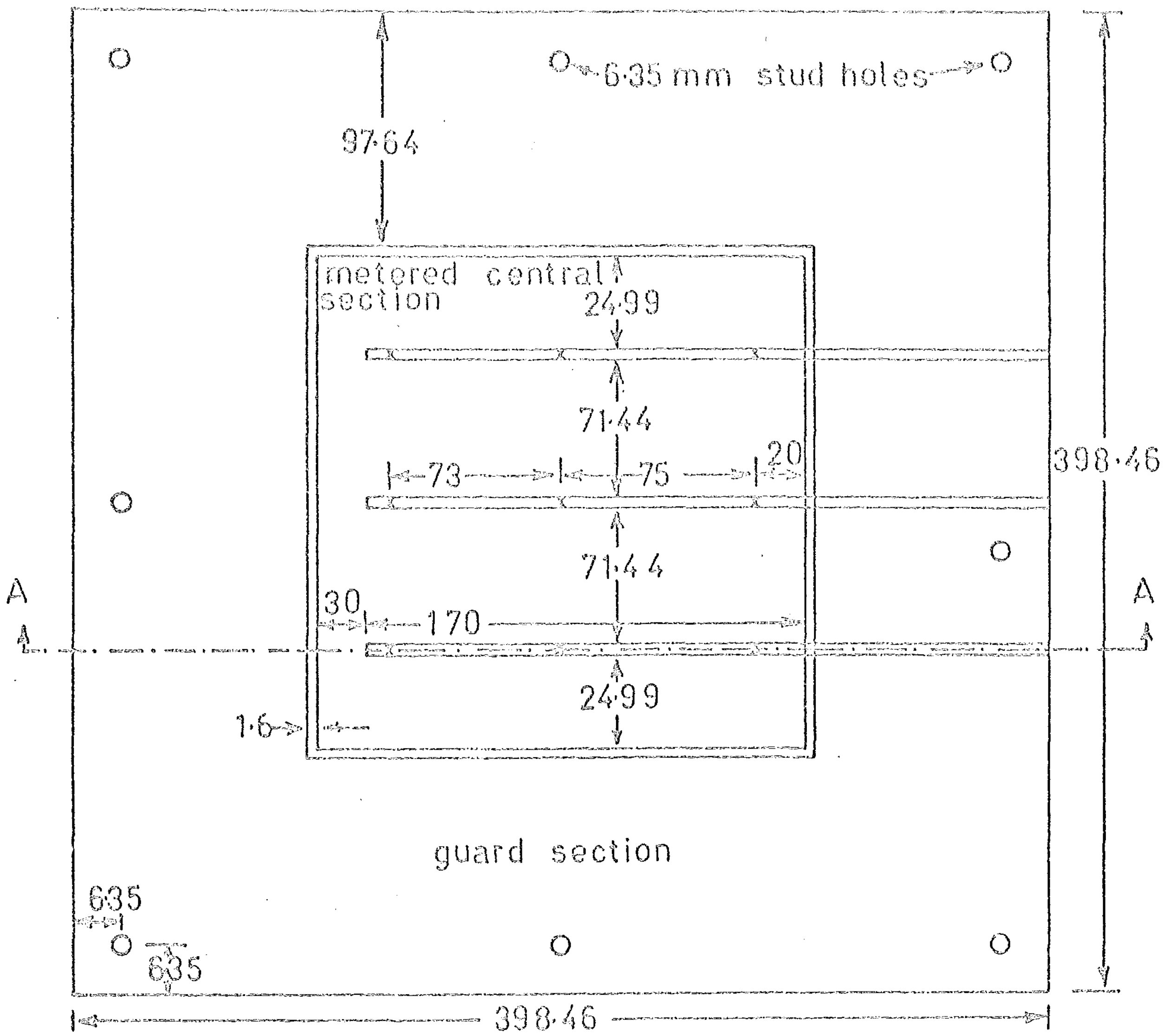
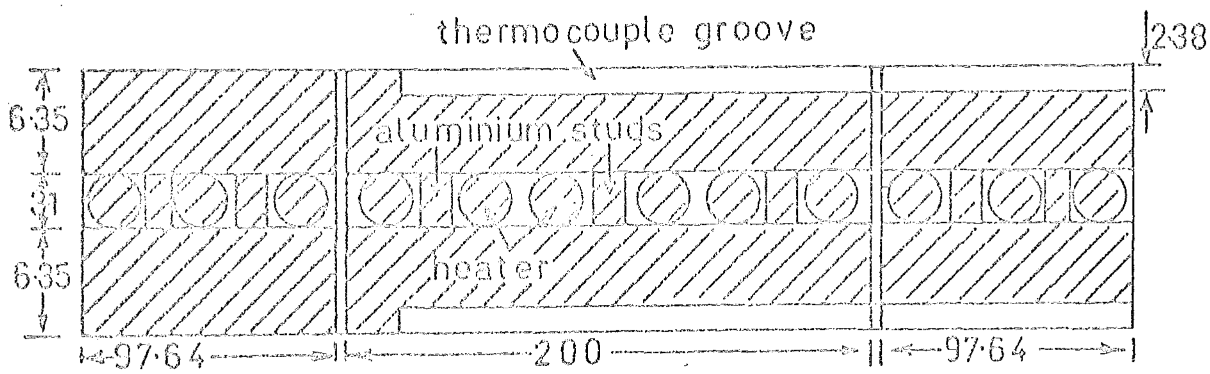


FIGURE 2-6



(A) PLAN VIEW OF THE HOT GUARDED PLATE



(B) SECTION A A

x–thermocouple positions
all dimensions in mm

FIGURE 2-7 HOT GUARDED PLATE

faces of the aluminium hot plate were machined to within $\pm$ 0.03mm (0.001"). Heat was supplied to the hot plate by 30 metres of pyrotenax heating cable (specifications in section 2.3.3). The cable was kept a constant diameter by the aluminium studs shown in Figure 2-7B.

2.3.1.2 Cold Plate

A section through the aluminium cold plates is shown in Figure 2-8. The heat sink (aluminium cold guarded plates) is made from two sheets of aluminium 398.5mm x 398.5mm x 6.35mm. These two sheets of aluminium were held together by eight aluminium screws on the outer edges of the plates, and by metal-to-metal adhesive in the centre of the plates. As in the hot plates, a metered central section and a guard section were provided. In fact, the plan view of each heat sink ('E' in Figure 2-4) is exactly the same as the plan view of the hot guarded plates (Figures 2-6 and 2-7).

2.3.1.3 Miscellaneous Plate Details

The cold plate construction described above was found to provide adequate cooling for the temperatures desired. The cold aluminium plates maintained a lower uniform temperature than that of the heating unit by thermal air insulation provided on the outermost faces. Polystyrene edge insulation was provided as shown in Figure 2-5. Polystyrene insulation was not used all around the apparatus because of the low temperature drops across the specimens (perspex especially). Consequently, to get large temperature drops, air was used as the thermal insulator. Experimental runs with fibreglass insulation right around the apparatus are described in Chapter 3.

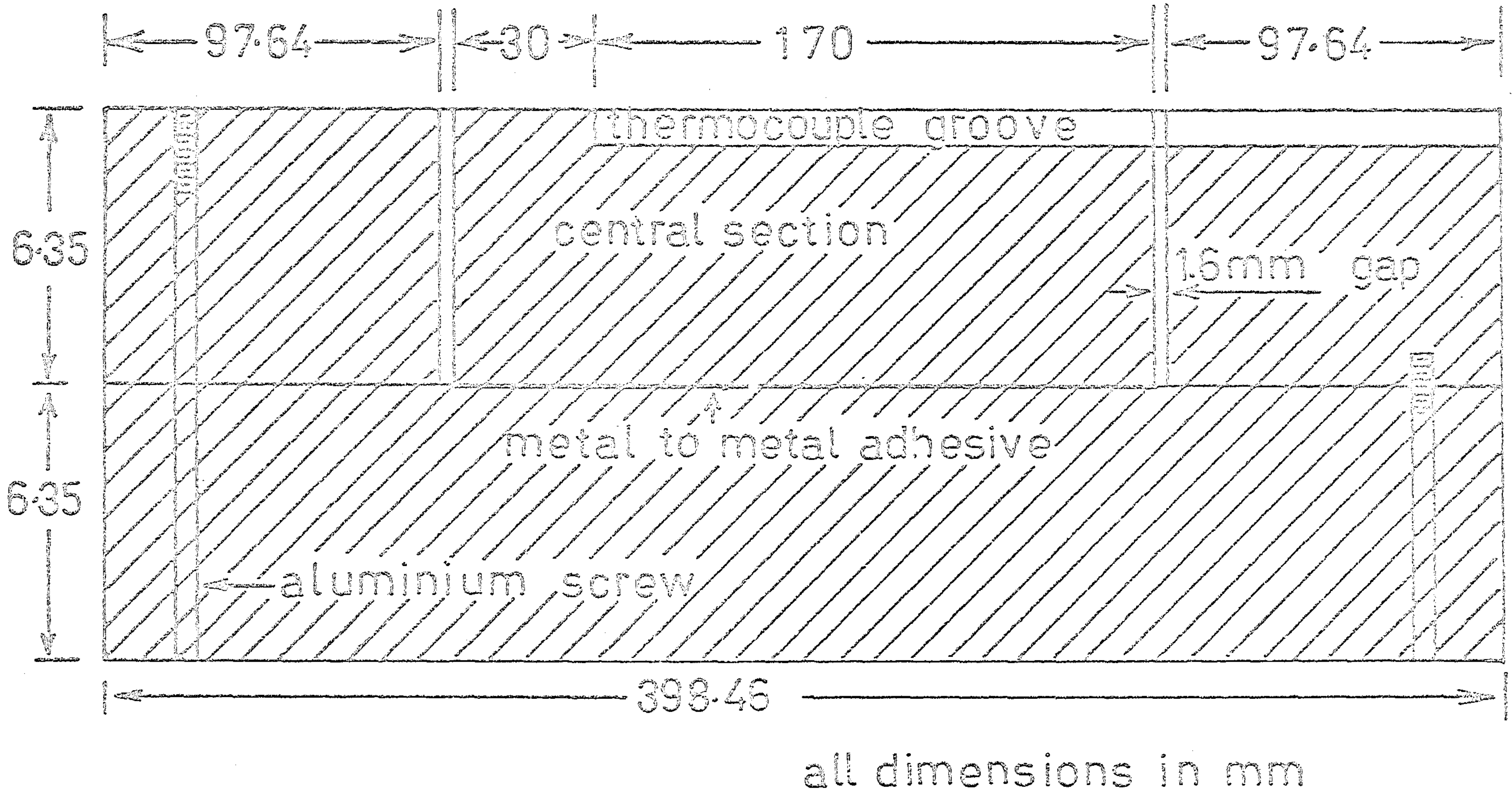


FIGURE 2-8 SECTION THROUGH COLD GUARDED PLATE

Figure 2-3 shows the guarded hot plate apparatus assembled. The aluminium support crossbars (one on top and the other at the bottom) are used for providing (a) rigidity to the assembled apparatus and (b) good thermal contact between the aluminium plates and the specimens. The plates are held together by using 1.6mm (1/16") stainless steel studs of varying lengths according to the thickness of the specimens. The studs are in 6.35mm (¼") holes so that they do not touch the aluminium plates. If they touched the aluminium plates, they would provide thermal short circuits for the heat flows.

Figure 2-6 shows the apparatus dismantled.

2.3.2 TEMPERATURE MEASURING EQUIPMENT

The surface temperatures of the guarded hot plate apparatus were measured using copper-constantan thermocouple wires. The reference junction, room, and water bath temperatures were measured by mercury-in-glass calibrated thermometers.

2.3.2.1 Thermocouple Wires

The thermocouple wires used were numbered from 1 to 37. Number 37 was the reference junction pair (Figure 2-9). Apart from showing the unassembled plates, Figure 2-6 also shows the guarded hot plate laid out in order of assembly. The thermocouple wires attached to the cold aluminium plates shown on the right in Figure 2-6 were numbered 1 to 9. The wires fixed on the top of the hot plate in Figure 2-6 were numbered 10 to 18. Those on the bottom of this plate were numbered 19 to 27. The wires attached to the cold plate shown on the left (with the aluminium studs in the Figure) were numbered 28 to 36.

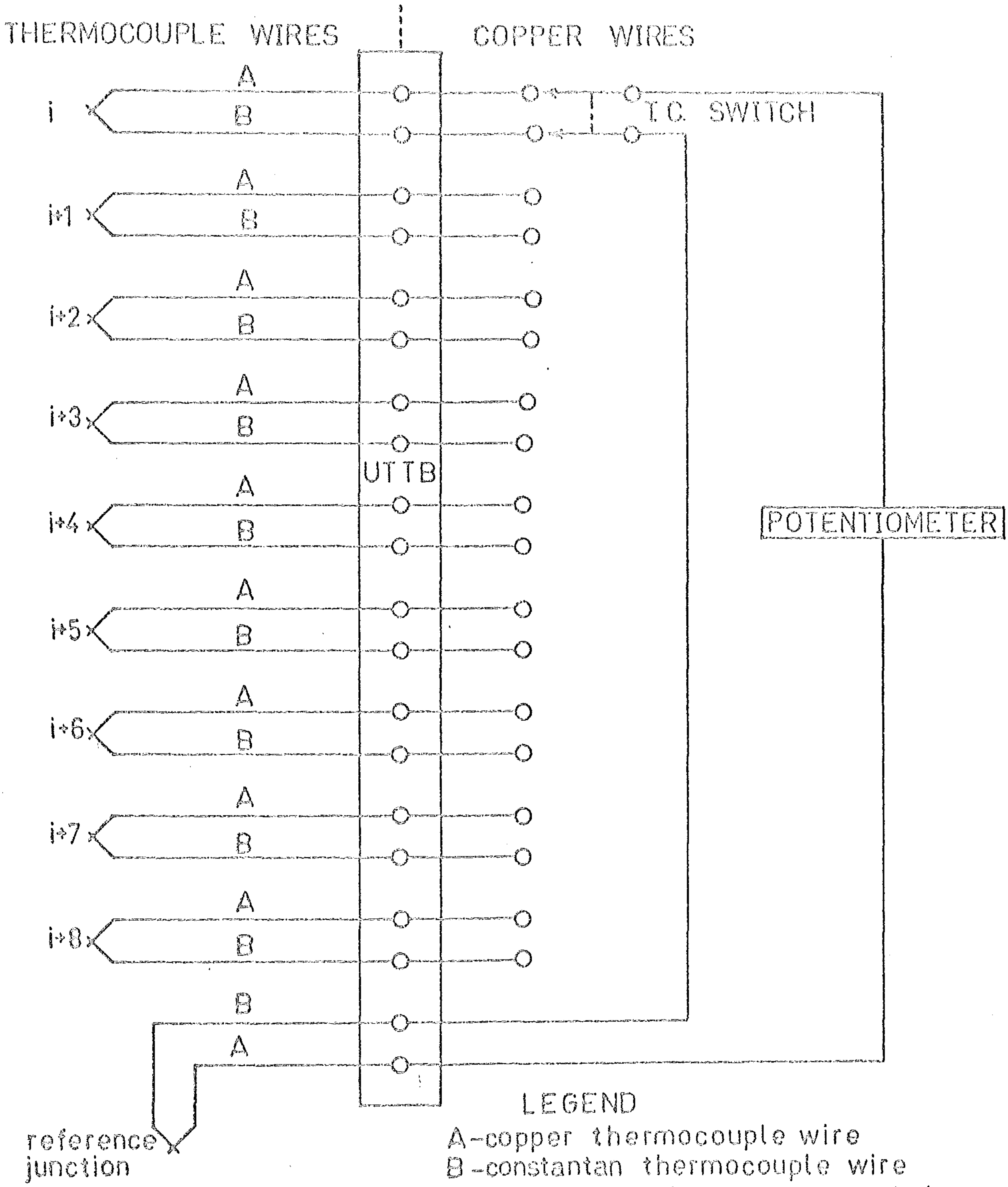
36 gauge copper wire was used as the positive leg of each pair and constantan as the negative leg. The copper wire was cotton-covered as supplied by British Driver Harris Company Limited. For thermocouple wires numbered 1 to 32, 36 gauge cotton-covered constantan wires was used, and for wires numbered 33 to 37, 39 gauge cotton-covered constantan wire was used. The differences between the resulting thermocouple pairs are discussed in the calibration section.

2.3.2.2 Thermocouple Circuit

Figure 2-9 shows the thermocouple circuit used. For ease of numbering the measuring junctions associated with each thermocouple pair, a measuring counter 'i' is used in Figure 2-9. For thermocouple wires numbered 1 to 9, i = 1; for wires 10 to 18, i = 10; for wires 19 to 27, i = 19; and for thermocouple wires numbered 28 to 32, i = 28. The terminal block three metres away from the measuring junctions was maintained at a uniform temperature by insulating with polystyrene and fibreglass insulation. All the junctions including one from the reference junction were brought to it. Copper wires were then led to the insulated double pole selector switch and on to the potentiometer.

2.3.2.3 Thermocouple Circuit Equipment

The thermocouple selector switch is a 'CROPICO' - 2 pole, 50 position manual rotary switch with a motorised option which was not used. The switch has gold-silver alloy contacts on copper studs ensuring low invariable contact resistance and negligible thermal emfs. This switch is model S.P.2, instrument number 20085 and was supplied by



LEGEND

A-copper thermocouple wire

B-constantan thermocouple wire

T.C.-thermocouple selector switch

i--measuring junction counter

UTTB-uniform temperature terminal block

FIGURE 2-9 THERMOCOUPLE MEASURING CIRCUIT

Croydon Precision Instrument Company.

The potentiometer used for measuring the thermocouple wire outputs was a Cambridge Laboratory precision potentiometer, type 44228. This potentiometer was designed primarily for the measurement of d.c. potentials up to 101mV. Two potential dials are provided. The main potential dial controls a multi-point switch that has 100 steps of 1mV, each step being defined by a light, positive 'click stop'. The contact surfaces of the switch are plated with rhodium. The fine potential dial, controlling a calibrated slide wire, has a range of -0.05mV to +1.05mV, giving an overlap of 0.05mV above and below each step of the main potential dial. It is divided at intervals of 0.01mV, allowing estimations of 0.002mV, and can be turned continuously through maximum back to minimum reading.

The galvanometer fitted with the potentiometer was disconnected from the potentiometer terminals by removable links. A Kipps-Zonen galvanometer with about twenty times the sensitivity of the Cambridge galvanometer was connected to the potentiometer terminals. The Kipps-Zonen ('microva') galvanometer used had a full scale deflection of 20cm for a measuring range of 2 microamps at an internal resistance of 125 ohms.

The specifications of the potentiometer can be summarised as follows:

Range: 101mV

Voltage Subdivisions: 100 steps of 1mV (main dial)
110 divisions of 0.01mV over

range of -0.05 to +1.05mm
(fine dial)

Accuracy: ± 0.1% or ½ slidewire division (0.005mV), whichever is the greater

Discrimination: 0.002mV

Resistance: 200 ohms/V

2.3.2.4 Reference Junction

The reference junction built was based on the constant temperature ice bath model E962 designed by the Rosemount Engineering Company Ltd. The reference junction set-up is shown in Figures 2-1 and 2-10. The ice bath consists of a 3.5 litre dewar flask, surrounded by polystyrene insulation. The dewar flask is 200mm deep and is of 150mm inside diameter. Distilled water and flaked ice made therefrom are used as the bath medium. The reference junction thermocouple wires are contained in a 3mm O.D. x 2mm I.D. glass tube. The tube is tapered to 1mm O.D. at the measuring junction end. The reference junction thermocouple pair was immersed to a depth of 150mm.

Agitation of the ice bath medium was not required (see section 2.4). The ice bath temperature was measured by a calibrated mercury-in-glass ($-20^{o}C$ to $+20^{o}C$) thermometer.

2.3.3 ELECTRICAL POWER SUPPLY EQUIPMENT

The maximum available d.c. voltage (power) supply was 50 volts. As a result, when more than 50 volts was required, the flow diagram shown in Figure 2-2 had to be modified. The d.c. regulator was replaced by a rheostat (variac). The supply to the hot guarded plate was then regulated 230 volts a.c. mains supply.

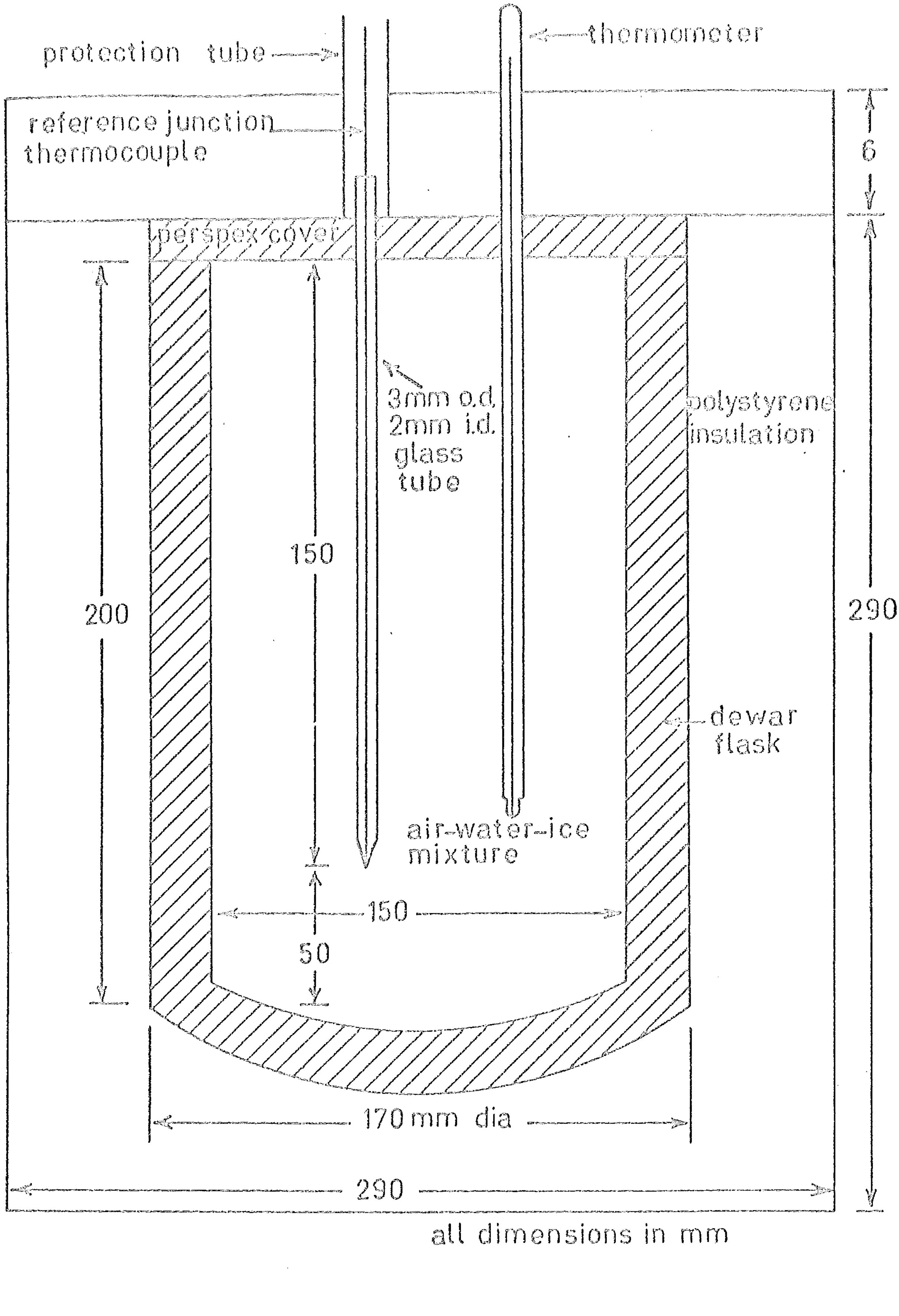


FIGURE 2-10 ICE BATH FOR REFERENCE JUNCTION

2.3.3.1 D.C. Regulated Power Supply

A Redfern regulated power supply series 51/3, 0-50 volts and 0-20 amps was used for the power supply to the hot plate. This unit converts 230 volts a.c. 50 cycles to 50 volts d.c. at 20 amps. The line voltage regulation is $\pm$0.01%, and the maximum ripple is 1mV RMS.

Direct current was the preferable power supply because it can be more accurately measured and is more steady than a.c. supply.

2.3.3.2 A.C. Regulated Power Supply

When a.c. power was required, the Sorenson a.c. voltage regulator model LT-1000-25 (used as the first stage voltage regulator in the d.c. circuit (Figure 2-2)), was used for the power supply to the hot plate.

The specifications of the Sorenson are:

Input Voltage: 230 volts a.c. mains

Output Voltage: 220-240 volts a.c. adjustable

Regulation Output: $\pm$ 0.1% for changes in input voltage
$\pm$ 0.01% for changes in load current

Distortion: 3%

Time Constant: 0.1 second

Power Factor Range: 0.9 leading to 0.7 lagging

2.3.3.3 Heating Element

Pyrotenax heating cable model HCH-1L-500 was used in heating the hot plates. The specifications for heating cable are:

Cable Diameter: 3.1mm

Resistance: 0.5 ohms per metre at 20°C

Maximum Working Temperature: $250^{\circ}C$

Maximum Voltage: 600 volts

2.3.3.4 Power Measuring Instruments

Two Data Precision Corporation miniature digital multimeters model 245 were used to measure the current and voltage into the aluminium hot plates.

These 4½ digit multimeters are for measuring d.c. or a.c. voltage, d.c. or a.c. current, or resistance with 0.005% resolution in 21 ranges and 100% overrange.

2.3.4 AUXILIARY EQUIPMENT

2.3.4.1 The Thermostatic Bath

The tank containing the cooling water was made out of stainless steel. The tank is 51cm x 51cm x 51cm. The agitation of the water in the tank was achieved by using a 10cm, 6 blade impeller driven by a 100 watt motor. The tank was insulated by 6.35mm thick polystyrene all around, with the top covered by 6.35mm thick sheets of perspex.

The temperature of the water in the tank was kept at a constant value by using a proportional controller. The maximum power output of the controller was 1500 watts. The controlled immersion heater had a resistance 50.5 ohms while the main uncontrolled water heater had a resistance of 35.6 ohms. The temperature sensor connected to the controller was a thermistor probe of resistance 10 kilo-ohms.

The stainless steel container (box) for enclosing the guarded hot plate apparatus under water was made out of 14 gauge stainless steel. The box was of dimensions 44.5cm x

15.24cm x 44.5cm. The flanged cover of the box had a 1.91cm I.D. x 15cm stainless tube for passing the thermocouple wires in and out of the box. The box was made water tight by using a gasket, gasket-sealing compound, and 18 bolts in the flange assembly.

The thermostatic bath is shown in Figure 2-11.

2.3.4.2 Miscellaneous Equipment

During the experimental runs, to establish when steady-state conditions had been attained, a graphical output from a thermocouple pair was obtained on a Kipps and Zonen BD5 recorder. The micrograph BD5 was primarily designed for recording a wide range of currents and voltages from 20nA and 20 microVolts full scale deflection up to 0.1mA and 0.1 volts full scale deflection. The accuracy of this recorder is better than 0.5% f.s.d.

During the experimental runs in which a.c. power was used, the transformer used to reduce the mains voltage from 230 volts to the desired value, was a Yokohama Electric Works Ltd, Voltac-type-SB-5, 0 to 260 volts, 5 amp variac.

The thicknesses of all the specimens were measured using a micrometer screw gauge. The other linear dimensions were measured using a steel ruler.

2.3.5 SPECIMENS

Polymethyl methacrylate (perspex) was the primary material used. Other materials used were durotherm (asbestos cement board), particle board, syndanyo board, and polystyrene (to a less extent). In the calibration runs, rubber

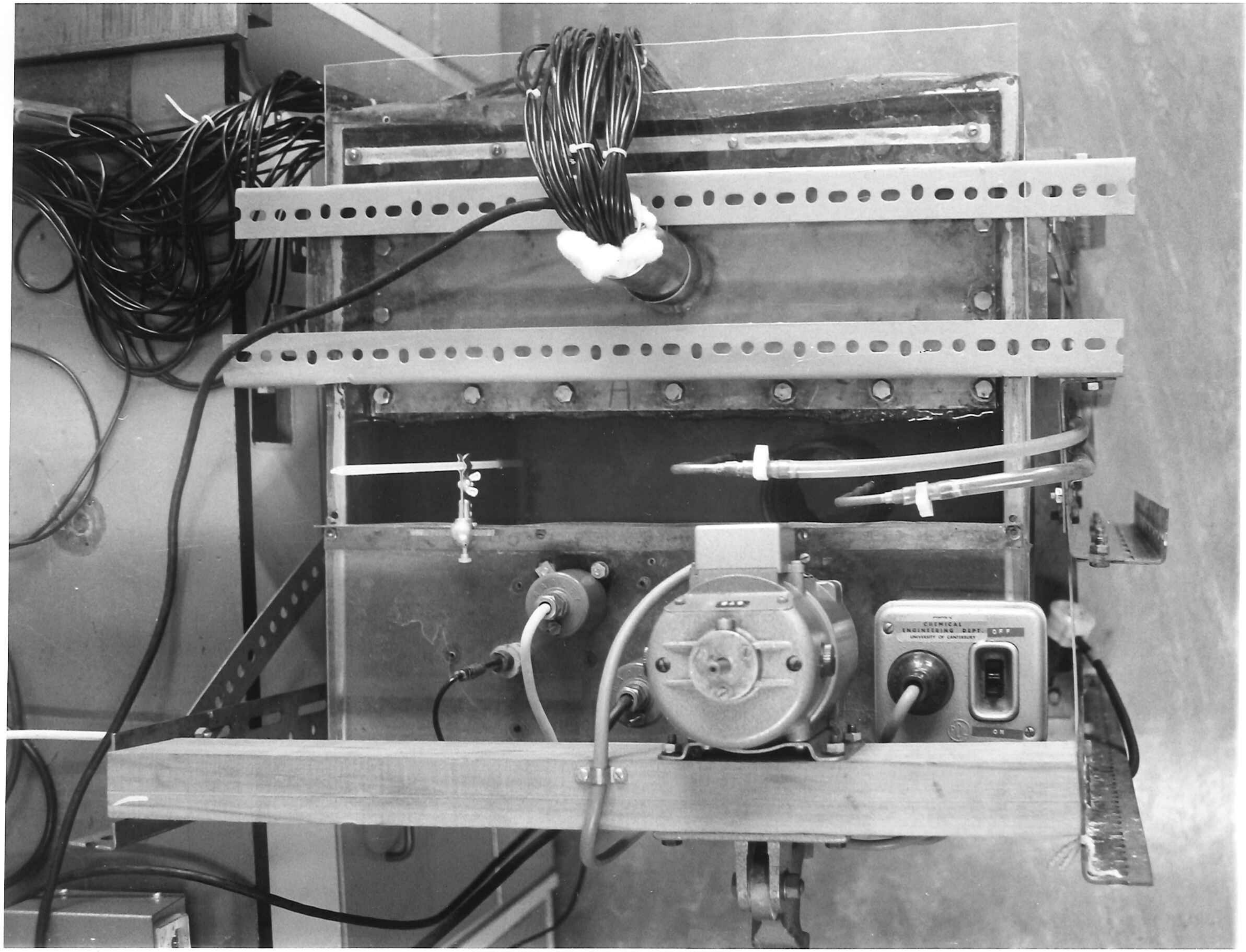

CHEMICAL
ENGINEERING DEPT.
UNIVERSITY OF CANTERBURY
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FIGURE 2-11

and cork board were also used but these were abandoned. Figure 2-12 shows some of the specimens used in the experiments. The specimens shown in the Figure have all had holes drilled in them. The 5.64mm thick perspex sheet also shows the aluminium foils put in the holes in an attempt to reduce radiation in the holes.

The specimens were all cut to the same size as the guarded hot plate, that is, 398.5mm square. The nominal specimen thicknesses were: 6.35mm, 12.7mm, and 19.05mm. The actual thicknesses of the individual plates are in the Appendix.

2.4 CALIBRATION OF EQUIPMENT

All the equipment used in this work was tested and calibrated prior to the main experimental runs (runs 1 to 738).

2.4.1 CALIBRATION OF THERMOCOUPLES

The calibration of a thermocouple consists of the determination of its electromotive force (emf) at a sufficient number of known temperatures so that, with some accepted means of interpolation, its emf will be known over the entire temperature range in which it is to be used. The process requires a standard thermometer to indicate temperatures on a standard scale, a means for measuring the emf of the thermocouple, and a controlled environment in which the thermocouple and the standard can be brought to the same temperature.

Much of the material described in this section including the techniques used are based on the methods of The National

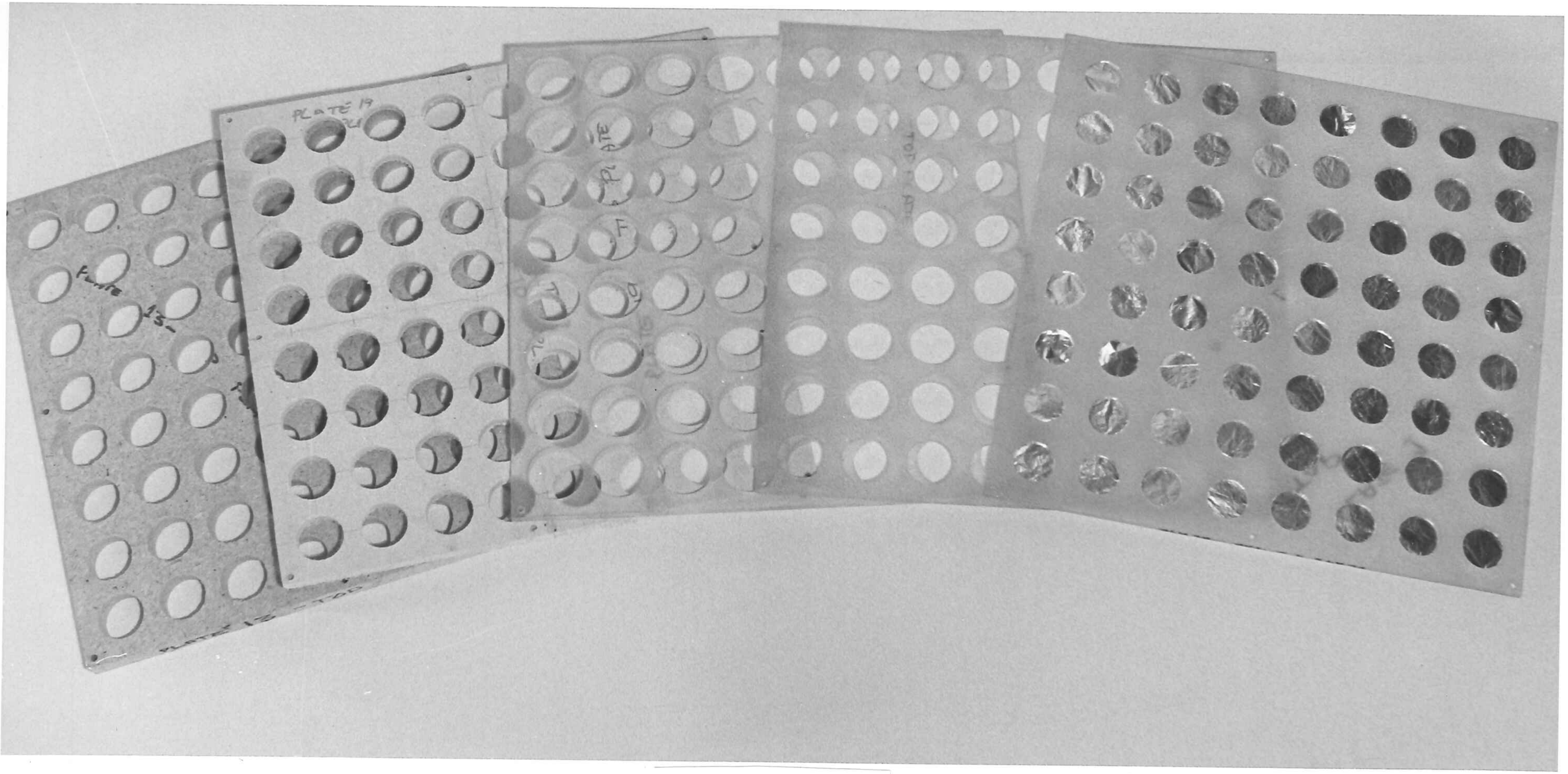


FIGURE 2-12

Bureau of Standards (138) and The National Physical Laboratories (139). Other useful references in the calibration of thermocouples are Billing (140), American Institute of Physics (118) and Baker (129).

2.4.1.1 Working Standard

The working standard used for the calibration of the thermocouple wires was the Rosemount Engineering Company platinum resistance thermometer model WS104. This thermometer was calibrated by the National Physical Laboratory in England in 1970, and by the New Zealand Department of Scientific and Industrial Research in late 1975. The former calibration was the more superior and complete. The latter was not conclusive, but it showed that the calibrations of 1970 were still valid. The brief specifications are presented here.

Temperature Range: $-183^{\circ}C$ to $500^{\circ}C$

Ice Point Resistance: 25.4899 ohms

25.4893 ohms

The results of the National Physical Laboratory calibrations are presented in the Appendix.

2.4.1.2 Measurement of emf

One of the factors in the accuracy of the calibration of a thermocouple, is the accuracy of the instrument used to measure the emf. In this work, the Cambridge potentiometer described in section 2.3.2.3 was used.

2.4.1.3 Calibration Using Comparison Method

The success of this method depends upon the ability of bringing the measuring junction of the thermocouple to the same temperature as the actuating element of the standard platinum resistance thermometer.

The maximum service temperature of perspex is 80°C. As a result, the temperature range of the work carried out was 0 to 80°C, and consequently, water was used as the bath medium.

The bath used is the same one described in section 2.3.4.1. The protection tube for immersion in the water bath is shown in Figure 2-13. The tube is drilled in a block of 70mm diameter x 360mm aluminium. The calibration zone is 10mm diameter by 245mm deep. Once the platinum resistance thermometer and the thermocouple wires have been inserted into it, the protection tube is filled with copper filings.

The reference junction described in section 2.3.2.4 and a three litre commercial dewar flask (10cm diameter x 40cm deep) were compared. Both were found to be suitable for the calibration of the thermocouples.

2.4.1.4 Procedure of Calibration Using the Comparison Method

(1) The water bath and the aluminium protection tube were maintained at a temperature close to the calibration temperature.

(2) The reference junctions described above were set up.

(3) The platinum resistance thermometer and the Model VLF 51A precision comparison bridge for resistance thermometry were set up. (Details in the Appendix.) The

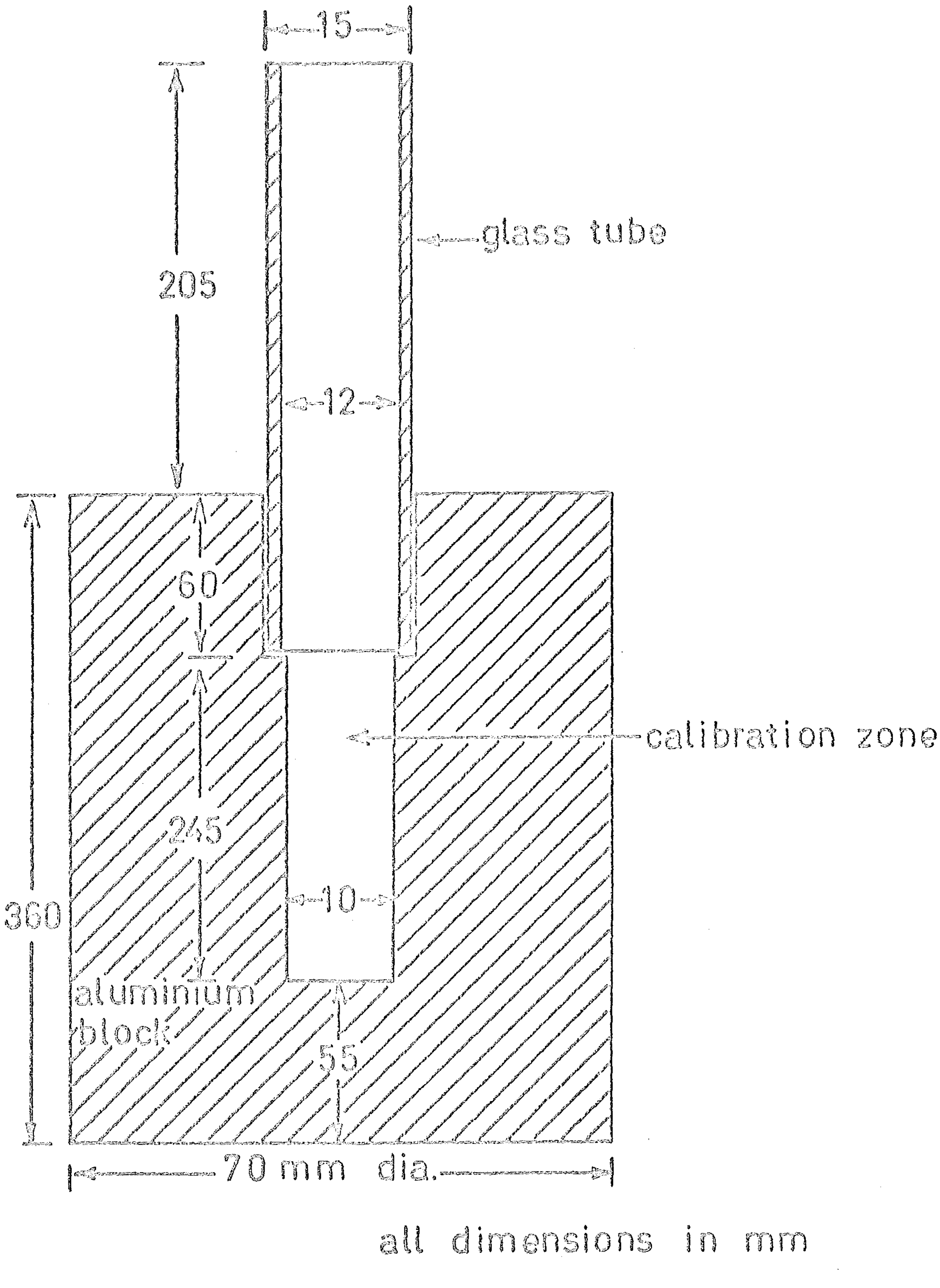


FIGURE 2-13 THERMOCOUPLE CALIBRATION BLOCK

various zero checks on the comparison bridge were performed.

(4) The ice point was checked by inserting the platinum resistance thermometer in the dewar flask.

(5) The platinum resistance thermometer and the four thermocouple wires numbers 5, 23, 33 and 35 were inserted in the protection tube which was already immersed in the water bath. Copper filings completely filled the calibration zone. The reference junction thermocouple wire (wire number 37) was put in the dewar flask (section 2.3.2.4).

(6) The water bath was brought to the required bath temperature using the controller and the bath thermometer ($\pm$ 0.1^{o}C). To ascertain when steady-state conditions had been attained, a graphical output from the thermocouple wires was obtained on a Hitachi two pen recorder and also by monitoring visually the controller fluctuations and the water bath temperature.

(7) Once steady-state was attained, the apparatus was left running in this condition for one hour. Monitoring the bath temperature with the thermometer and the Hitachi recorder was continued throughout this period.

(8) After equipment had been at steady-state for one hour, the following were noted down:

(a) the resistance ratio of the platinum resistance thermometer to the standard resister. This gives the bath temperature ex platinum resistance thermometer.

(b) the thermocouple wire outputs in millivolts

(c) the water bath temperature using the 1/10th of a degree mercury-in-glass thermometer

(d) the room temperature using the two wall thermometers

(e) cooling water rate, bias heater voltage, and the controller setting

(9) The apparatus was again left running at the steady conditions for a further hour. Procedure steps 7 and 8 were repeated.

(10) After two sets of readings were noted down for the same operating conditions, step 6 and the subsequent steps were repeated.

The relationship between the temperature and emf of copper-constantan thermocouples has been very well established in the literature in the range $-190^{\circ}C$ to $+300^{\circ}C$ (138,141). In the range $0^{\circ}C$ to $100^{\circ}C$, the relationship is a straight line. As a result, the calibration runs used in this work used water bath temperatures in the range $25^{\circ}C$ to $55^{\circ}C$.

2.4.1.5 Method of Interpolating Between Calibration Points

After a thermocouple has been calibrated at a number of points, the next requirement is a convenient means of obtaining corresponding values of emf and temperature at other points. Various interpolating methods are available in the literature (118,138,141).

For the copper constantan thermocouples used, the empirical relationship of the National Bureau of Standards (138) was used.

$$e = aT + bT^2 + c \qquad (2\text{-}1)$$

where e = emf in millivolts

T = temperature in ^{o}C

a and b are calibration constants

c is also a calibration constant which should be equal to zero

As mentioned in section 2.3.2, two different gauges of constantan wire were used in the experiment. Consequently, two calibration equations (and tables) resulted. Recall that thermocouple wires numbered 1 to 32 used 36 gauge constantan wire, whereas the wires numbered 33 to 37 used 39 gauge constantan wire. The calibration equations obtained are:

(a) for thermocouple wires 5 and 23:

$$e = 0.02786 + 0.03742\ T + 0.00004287\ T^2 \qquad (2\text{-}2)$$

(b) for thermocouple wires 33 and 35:

$$e = -0.007268 + 0.03905\ T + 0.00004037\ T^2 \qquad (2\text{-}3)$$

2.4.1.6 Discussion of Calibration Uncertainties

The several factors which contributed to the uncertainties in the emf versus temperature relationships given above may be grouped into two kinds.

2.4.1.6.1 Uncertainties which influenced the observations

- the accuracy attained at each calibration point was dependent upon the degree to which the platinum resistance thermometer and the thermocouples were maintained at the same temperature

- the accuracy of the platinum resistance thermometer

(the ice point was the only check)

- the stability and homogeneity of the 36 gauge wires
- the accuracy of the emf measure (potentiometer accuracy)

2.4.1.6.2 Uncertainties due to interpolation between calibration points

Interpolation between calibration points was based on the assumption that emf changes slowly and smoothly with temperature. Table 2-1 shows some temperatures obtained by evaluating equations 2-2 and 2-3 for experimental values of emf. The temperatures indicated by the platinum resistance thermometer are also presented. As can be seen from the results, the experimentally determined temperatures (the platinum resistance thermometer results) and the empirical (using interpolation equations) temperatures agree to within $\pm$ 0.04^{o}C. This is also the accuracy to which thermocouple wires can be relied on to retain their calibration.

TABLE 2-1

Experimentally and Empirically Determined Temperatures

Thermocouple Wire Outputs				Platinum Resistance Temperature in ^{o}C
Wires No 5 and 23		Wires No 33 and 35		
Average mV Output	Empirical Temperature ^{o}C	Average mV Output	Empirical Temperature ^{o}C	
1.031	25.58	1.071	25.56	25.58
1.192	30.08	1.204	30.08	30.06
1.437	36.16	1.458	36.17	36.17
1.688	42.32	1.718	42.33	42.30
1.856	46.39	1.8905	46.38	46.37
2.0185	50.30	2.058	50.28	50.31

The American Society for Testing and Materials manual STP470A (142) presents a very good review of uncertainties due to interpolation between calibration points.

2.4.1.7 Concluding Remarks

The emf-temperature relationships for the two types of thermocouple wires used in this work are given in quadratic equation form (Equations 2-2 and 2-3). The relationships are also presented in tabular form in the Appendix. In the computation of experimental results in Chapter 4, the temperatures are found by solving the quadratic equations.

The temperatures evaluated from the quadratic equations are accurate to $\pm$ 0.04^{o}C.

2.4.2 CALIBRATION OF REFERENCE JUNCTION

2.4.2.1 General Comments

If a proper technique is used, the uncertainty in the reference juntion temperature can be made negligibly small. With extreme care, the ice point can be reproduced to 0.0001^{o}C (142).

2.4.2.2 Working Standard

The platinum resistance thermometer described in section 2.4.1.1 was the working standard.

2.4.2.3 Calibration Method

The reference junction described in section 2.3.2.4 was used. The flask was filled with ice and its temperature determined using the platinum resistance thermometer. The results obtained were also compared with those obtained when the commercial three litre flask was used.

Experimental runs were also performed in which a stirrer was used. The above procedure was repeated at different times of the day and on different days.

2.4.2.4 Calibration Results

A typical set of ice point determinations is shown below.

TABLE 2-2

Ice Point Calibrations

Date	Reference Junction Temp. °C	Commercial Dewar Flask Temp. °C
08-12-75	0.001506	0.001511
08-12-75	-0.008277	-0.008476
08-12-75	-0.007274	-0.006910
08-12-75	-0.006521	-0.006800
22-12-75	0.000502	0.000504

The ice point readings with the reference junction media being stirred were not successful due to the stirrer motor noise causing fluctuations in the precision comparison bridge null meter.

2.4.2.5 Concluding Remarks

The reference junction used in all the experimental runs in this work was kept at $0^{\circ}C$ ($-0.008^{\circ}C$ to $0.007^{\circ}C$).

2.4.3 CALIBRATIONS OF INSTRUMENTS USED WITH THERMOCOUPLES

The Cambridge potentiometer described in 2.3.2.3 was the instrument used to provide a measure of any unknown electromotive force. As no standard potential measuring instrument was available, the calibration of the potentiometer consisted of comparing its emf outputs against those of other available potentiometers.

Table 2-3 shows a typical set of results. Potentiometer 'A' represents the one used in the experiments, and 'B' represents another Cambridge potentiometer.

TABLE 2-3

Comparison of Two Cambridge Potentiometers

Thermocouple Wire Number	Potentiometers A	B
5	1.332mV	1.335mV
23	1.332mV	1.329mV
33	1.349mV	1.345mV
35	1.349mV	1.345mV
5	1.583mV	1.584mV
33	1.608mV	1.605mV

Numerous other test runs were performed to validate the readings indicated by the potentiometer. These included comparing the potentiometer readings with those of a solartron digital datalogger, and those shown by the Data Precision Corporation digital multimeters.

The Kipps-Zonen galvanometer was, of course, not calibrated since it was used to indicate the presence of a current, and readings were only made when no perceptible current was passing through it.

2.4.4 CALIBRATION OF POWER SUPPLY EQUIPMENT

As the experiments were performed at steady-state, it was essential to have constant power supply. The regulations in the supply achieved are indicated in the various experimental runs in the Appendix. Better regulation was achieved through isolation of all the electrical equipment via transformers.

The two digital multimeters used for the current and voltage measurements were calibrated against a standard digital multimeter. For both meters and for all ranges, the indicated readings were exactly the same as those of the standard. These calibration checks were undertaken at various stages of the experimental work.

2.4.5 CALIBRATION OF PLATES

In any guarded hot plate apparatus, it is absolutely essential to get the plates as identical as possible.

2.4.5.1 Flatness of the Plates

Trial experimental runs with unmachined perspex pieces were carried out (experiment series A - Chapter 3). It was found necessary to machine the perspex pieces due to the variations in thicknesses of as received specimens. All the perspex specimens used in the experiments (series B and some of series A) were machined flat to within $\pm$ 0.03mm (0.001").

The flatness of the aluminium plates has already been discussed (section 2.3).

2.4.5.2 Temperature Drops Across The Specimens

One of the factors noted during pre-trial and trial runs was the difference in temperature drops between the two specimens ('a' and 'b' in Figure 2-5). For example, results shown in Table E1.

Mathematically,

$$(mv_{10-18} - mv_{1-9}) \text{ is not equal to } (mv_{19-27} - mv_{28-36}) \qquad (2\text{-}4)$$

where mv_{i-i+8} is the average millivolt reading of thermocouple wires i to i+8.

Equation 2-4 unfortunately held for all the runs. The causes of the 'temperature-drop' differences could have been:

(1) differences between the specimens

(2) the assumption of even heat flux distribution between the two specimens not being true

(3) different positions of the thermocouple wires (This was highly unlikely since each plate had nine different thermocouple wires.)

(4) different external heat flow resistances (resistances due to insulation in the enclosure)

(5) differences between the aluminium plates

(6) arrangement of the apparatus - the positioning of the guarded hot plate in the enclosure and in the bath

The above uncertainties were experimentally investigated.

2.4.5.2.1 Determination of 'temperature-drop' differences

In an attempt to get the temperature drops across the specimens to be the same, an extensive experimental and theoretical program was undertaken.

The uncertainty due to the specimen physical and chemical structures was minimised by cutting the perspex pieces from the same large sheet. During any set of experimental runs, it was also decided to do a check on the effect of the specimen position in relation to the aluminium plates. After each experimental run, the specimen positions were exchanged. In Figure 2-5, specimen 'a' was put where specimen 'b' was and vice versa. Readings were again taken.

The heat flux distribution uncertainty was minimised by putting aluminium studs in the hot plate (Figure 2-7). Physical and chemical differences between the aluminium plates used were minimal. All the aluminium plates used in the guarded hot plate apparatus were made from the same sheet of material.

The effect of the external resistance on the temperature drops was investigated by using three types of insulation systems in the box.

(i) sheets of polystyrene completely enclosed the guarded hot plate

(ii) fibreglass insulation instead of polystyrene

(iii) air was also used instead of polystyrene

The use of plastic bags instead of the stainless steel box was also investigated unsuccessfully. The bags kept on getting torn regardless of the number used.

The effect of the arrangement of the apparatus was thoroughly investigated. Using 6.35mm thick perspex pieces, six arrangements were considered. With reference to Figure 2-5, the side of the stainless steel box nearest to the cold aluminium plate labelled 11a was labelled Side 'a'.

<u>Run I</u> - The apparatus was arranged as shown in Figure 2-5. However, the polystyrene studs ('9') were replaced by sheets

of polystyrene completely filling the box.

Run II - The arrangement of Figure 2-5 was used.

Run III - Same as run II but at a different voltage and current setting, consequently, different temperature drops.

Run IV - The guarded hot plate apparatus was rotated inside the box. The cold aluminium plate 11b was now closest to side 'a' of the stainless steel box.

Run V - The same arrangement as run IV except that the specimens 'a' and 'b' were swapped. The former specimen was now closest to side 'a' of the box.

Run VI - The same arrangement as run V except that the stainless steel box with all its contents was completely rotated during this run. Side 'a' of the box was now closest to the stirrer assembly in Figure 2-5.

2.4.5.2.2 Results of the positioning experiments

Table 2-4 shows:

(a) the average temperature of each plate for all the six runs

(b) the corresponding temperature drops across the specimens

(c) the thermocouple wires used in determining the surface temperature

Experimental Observations - From the experimental results presented in Table 2-4, the following points arise:

(1) The temperature of cold plate 11a is always greater than that of cold plate 11b.

(2) Within the thermocouple calibration error limits ($\pm$ 0.04^{o}C), the two hot aluminium plates 13a and 13b have

TABLE 2-4

Results of Positioning Arrangement Experiments

Run	Temperature of cold plate 11a Thermocouple Wires numbers 1-9		Temperature of hot plate 13a Thermocouple Wires numbers 10-18		Temperature Drop Across Specimen	Temperature of hot plate 13b Thermocouple Wires numbers 19-27		Temperature of cold plate 11b Thermocouple Wires numbers 28-32		Temperature Drop Across Specimen	Difference in 'Temperature-Drops'
	mV	°C	mV	°C	°C	mV	°C	mV	°C	°C	°C
I	1.970	49.12	2.051	51.06	1.94 (a)	2.050	51.04	1.950	48.64	2.40 (b)	0.46
II	1.770	44.30	1.861	46.50	2.20 (a)	1.862	46.52	1.762	44.10	2.42 (b)	0.22
III	1.952	48.71	2.080	51.77	3.06 (a)	2.081	51.80	1.943	48.49	3.31 (b)	0.25
IV	1.947	48.59	2.075	51.66	3.07 (a)	2.077	51.70	1.941	48.44	3.26 (b)	0.19
V	1.943	48.49	2.071	51.56	3.07 (b)	2.072	51.58	1.939	48.40	3.18 (a)	0.11
VI	1.949	48.64	2.078	51.73	3.09 (b)	2.079	51.75	1.945	48.54	3.21 (a)	0.12

Note: The letter in the brackets refers to the specimen used. For example:

1.94°C (a) - refers to the temperature drop across specimen 'a'

3.07°C (b) - refers to the temperature drop across specimen 'b' equal temperatures. Consequently, the even heat flux assumption was verified.

(3) The temperature difference of the specimen held between plates 11a and 13a is always less than that of the specimen held between plates 11b and 13b. This naturally follows from points (1) and (2).

(4) The more the insulation put in the box, the lower the temperature difference across the specimen. This point is further verified in Chapter 4. From runs II and III, as expected, the higher the working temperature, the higher the difference in 'temperature-drops' between the two specimens.

2.4.5.2.3 Concluding remarks

It was not possible to get the temperature differences across the specimens the same. Equation 2-4 was not able to be falsified. The insulation in the box was at first thought to have been the source of temperature differences between the two cold aluminium plates 11a and 11b. This point was later nullified by the experimental runs with durotherm at high temperatures using both air insulation and fibreglass insulation. These results are discussed in Chapter 5.

The 'temperature-drop' difference between any two specimens was incorporated in the overall experimental error.

2.5 EXPERIMENTAL PROCEDURE

2.5.1 APPARATUS PREPARATION

Once the apparatus had been built, tested and calibrated, the main experimental runs started.

(1) A material (specimen) of correct thickness was

chosen, usually perspex.

(2) Two pieces of the material 398.5mm square were cut from the same sheet.

(3) The pieces were machined to the same thickness to within $\pm$ 0.03mm. The pieces were also marked so that they could be distinguished. For example, 6.35mm nominal thickness perspex pieces were marked 'plates 1 and 2'.

(4) The correct length studs for clamping the guarded hot plate were screwed in the appropriate cold aluminium plate.

2.5.2 ASSEMBLY OF APPARATUS

(1) The marked specimens were put between the appropriate plates.

(2) Using the four corner studs, the plates were clamped lightly.

(3) The guarded hot plate was then clamped firmly using the four middle studs and the support crossbars. The four corner studs were also tightened firmly.

(4) The guarded hot plate was then put in the stainless steel box (enclosure).

(5) Using the gasket compound, the gasket, and eighteen bolts, the box was made water tight by bolting the flange cover on top.

(6) The box containing the guarded hot plate was immersed in the water bath (Figure 2-11).

(7) The water bath was brought to temperature (31^{o}C) using the controller, bias heater, cooling water and the stirrer.

The guarded hot plate was then connected to the electrical power supply. The temperature of the guarded hot plate was monitored on the Kipps-Zonen BD5 recorder.

2.5.3 OPERATION OF APPARATUS

The operating procedure was adopted from that outlined in the A.S.T.M. Standard C177-71.

For any test, the temperature difference between the hot and cold surfaces of the specimen was adjusted by varying the power supply. From trial experimental runs using perspex, three voltage settings were chosen. These were 17 volts, 35.4 volts and 44.6 volts. During later experimental runs, higher voltages (55 volts and 63 volts) were used. For other materials, syndanyo board, for example, 132 volts was one of the voltage settings used.

The operating procedure was:

(a) A voltage setting was chosen. The apparatus was left running at this setting until steady-state was attained (usually after 36 to 48 hours).

(b) Once the Kipps-Zonen recorder indicated steady-state, the following were noted down:

(i) the room temperature using the two wall thermometers

(ii) the time of day

(iii) the water bath temperature

(iv) the reference junction temperature (always $0^{\circ}C$)

(v) the current and voltage - using the two digital multimeters

(vi) all the thermocouple wire outputs (numbers 1 to 36) using the Cambridge potentiometer

(vii) after all the thermocouple wire outputs were taken, steps (i) to (v) were again repeated - (thus all the environmental conditions were noted down before and after each set of millivolt readings)

The above procedure ((i) to (vii)) was repeated every hour, thirteen times for every voltage setting. Note that after all the perspex experimental runs, the procedure was repeated every half hour and only eight times for durotherm, wood, syndanyo board and polystyrene runs.

2.5.4 EXPERIMENTAL DETERMINATIONS

2.5.4.1 Thermal Conductivity

Once a material had been chosen and prepared, its thermal conductivity was determined at various mean temperatures (various voltage settings). For example, the thermal conductivity of durotherm (plates 19 and 20) was determined at 66°C, 80°C, 92°C and 130°C. During some of the thermal conductivity determinations, especially perspex runs, the positions of the specimens were altered by exchanging them exactly as described in run IV (section 2.4.5.2.1). The exchanging was a means of getting an estimate of the experimental error.

2.5.4.2 Thermal Conductance

Once the thermal conductivity of the material was known at various temperatures, the following procedure was adopted:

(i) A hole size to be investigated was chosen. For perspex specimens, the initial hole size chosen was 30.5mm diameter.

(ii) Holes were drilled in the specimen in a regular pattern (square pitch) as shown in Figure 2-12.

(iii) The thermal conductances of the specimens with holes in them were determined as described above (2.5.3).

(iv) The hole size in the specimens was increased. For perspex pieces, 35.5mm diameter holes were used. Step (iii) was then repeated. For perspex plates 5 and 6, 40.5mm diameter holes were also used.

For durotherm, only one size hole was used (34.925mm diameter).

2.5.4.3 Thermal Conductance With Aluminium Foil in the Holes

For perspex specimens with 30.5mm holes, aluminium foil inserts were placed in the centre of each hole, and the thermal conductance was measured.

CHAPTER 3

QUALITATIVE RESULTS

CHAPTER 3

QUALITATIVE RESULTS

This chapter deals with descriptions, aims and scope of the results obtained from both the experimental and the theoretical runs.

3.1 QUALITATIVE EXPERIMENTAL RESULTS

The apparatus being basically complete, and calibrated, experimental runs were carried out in two series.

3.1.1 EXPERIMENTS - SERIES A

This series of runs was carried out as a trial for the apparatus. The numerous experiments carried out will not be described individually since many of them proved abortive. This series of runs provided the basis for the major modifications that the apparatus underwent before the main experimental runs (Series B).

The first few runs used 6.35mm thick sheets of rubber as the specimens. Spacers were used to compress the two specimens to the same thickness. The cold surface of the rubber specimens was kept at 33°C and the hot surface at 39°C. Large differences (50-75%) between the two specimens were observed. These were probably due to the unequal compressions resulting from the different specimen widths. The rubber specimens were also run at high temperatures (T_{hot} = 91°C and T_{cold} = 80°C). At these high temperatures the experimental results were invalidated by thermal creep of the rubber specimens (143). Since rubber gave results which were not compatible within experimental error limits, it was abandoned as a specimen.

Runs with cork board as the specimen material were tried next. The 6.35mm thick cork board specimens were clamped between the aluminium plates which were put in plastic bags and then immersed under water. The plastic bags ensured an intimate contact between the aluminium plates and the water in the bath as hydrostatic pressure removed all the air in the bags. Even at low temperatures, the resulting temperature drops across the specimens were high. When the specimen hot surface was at 45.3^{o}C, the corresponding cold surface temperature was 35.2^{o}C. These temperature drops were very propitious. The ability of the cork board to retain its chemical composition was in doubt as the esters used in the adhesives to hold the board together were smelt after two hours' heating. Although the plastic bags (five layers used at a time) ensured thermal equilibrium within three hours, most runs had to be abandoned since the bags leaked.

With the rubber and cork board specimens abandoned, the next available material tried was perspex. Runs with 6.35mm thick clear and translucent (white opal) perspex specimens unmachined were undertaken. The specimens were enclosed in plastic bags instead of the stainless steel box. The clear perspex runs were completed without the bags leaking. However, sometime during the white perspex runs, the bags leaked. Consequently, the white perspex results presented in the Appendix are suspect. Since only one thickness of translucent perspex was available, it was decided not to use it in the main experimental runs.

The clear perspex runs described above were so successful that it was decided to drill 30.5mm diameter holes in them and measure the resulting conductances. The runs were performed using the 5.94mm and 5.74mm thick specimens. Fortunately, the plastic bags did not leak during this set of runs. The results are presented in the Appendix.

From the qualitative and quantitative results of experiment Series A, it was decided:

(a) to machine all specimen pieces before runs

(b) to abandon plastic bags in favour of the stainless steel box enclosure which was proven to be water tight but took longer to reach thermal equilibrium

3.1.2 EXPERIMENTS - SERIES B

This series of runs constitutes the main and final experiments undertaken in this work. The detailed results are in the Appendix. Sample calculated results are presented in Chapter 4. The runs are numbered from 1 to 738. For the various experiments, Tables 3-1 to 3-5 show:

(a) the specimens used - numbers and thicknesses

(b) the specimen positions in the guarded hot plate

(c) the conditions of the experiments - mean temperatures (heater voltage settings)

The experiments fall into three broad classes.

3.1.2.1 The Determination of the Thermal Conductivity of Perspex

During runs 1 to 158, the thermal conductivities of 5.6mm and 11mm thick perspex pieces were determined. The 5.6mm thick specimens were numbered plates 1, 2, 3, and 4. The 11mm thick specimens were numbered plates 5, 6, 7, and 8.

With reference to Figure 2-5, the specimens were positioned in the guarded hot plate apparatus as follows:

(a) the even numbered specimens were placed between the aluminium plates 11b and 13b

(b) while the odd numbered specimens were placed between the aluminium plates 11a and 13a

(c) as previously mentioned (Chapter 2), the specimen positions were exchanged for at least one run to get an estimate of the experimental error

Statements (a) and (b) above can be expressed as follows:

<u>For even numbered specimens:</u>

cold surface temperature = mv_{28-36} (3-1)

hot surface temperature = mv_{19-27} (3-2)

where mv_{i-i+8} is the average millivolt reading of thermocouple wires i to i+8.

<u>For odd numbered specimens:</u>

cold surface temperature = mv_{1-9} (3-3)

hot surface temperature = mv_{10-18} (3-4)

The above comments refer to all the other runs as well (runs 1 to 738).

3.1.2.2 The Determination of the Thermal Conductance of Perspex With 30.5mm Holes Drilled

The perspex specimens used in runs 1 to 158 had 30.5mm holes drilled in them. In runs 159 to 457, the thermal conductances of these specimens were determined. Some of the experimental runs involved perspex pieces with aluminium foil inserts in the holes. The presence of the aluminium foil inserts is indicated in Table 3-2 by an asterisk next to the run number.

3.1.2.3 Miscellaneous Experimental Runs

These cover runs 458 to 738 and they consist of the following:

(a) thermal conductivity and conductance determinations of 20mm thick particle board (plates numbered 13 and 14)

(b) thermal conductivity determinations of 19mm (nominal thickness 3/4") thick perspex (plates numbered 9 and 10)

(c) thermal conductivity determinations of 9.7mm thick syndanyo board (plates numbered 15 and 16)

(d) thermal conductivity and conductance determinations of durotherm (plates numbered 19 and 20)

(e) thermal conductance determinations of perspex plates 5 and 6 (11mm thick) with various hole sizes and at various mean operating temperatures

(f) thermal contact resistance determinations using 19mm thick perspex sheets (plates 11 and 12)

(g) thermal conductance determinations across air spaces - the hot and cold aluminium plates of the guarded hot apparatus were separated by 5 spacers (5mm diameter x 11mm long). (The spacers were numbered fictitious plates 21 and 22.)

(h) thermal conductivity determinations of 12.7mm thick polystyrene (plates numbered 17 and 18)

Runs 458 to 738 are summarised in Tables 3-3, 3-4 and 3-5.

TABLE 3-1

Runs 1 to 158 - Thermal Conductivity of Perspex Determination

(Experimental Conditions)

Runs	Specimens Nominal Thickness mm	Specimen Held Between Aluminium Plates		Approximate Mean Temperature °C	Voltage Setting Volts
		11a and 13a	11b and 13b		
1 - 14	5.6	1	2	50	35.4
15 - 28	5.6	3	4	50	35.4
29 - 42	5.6	3	4	36	17.0
43 - 55	5.6	3	4	60	44.6
56 - 68	5.6	4	3	50	35.4
69 - 80	5.6	2	1	50	35.4
81 - 93	11	5	6	50	35.4
94 - 106	11	5	6	36	17.0
107 - 119	11	5	6	60	44.6
120 - 132	11	6	5	50	35.4
133 - 145	11	7	8	50	35.4
146 - 158	11	8	7	50	35.4

TABLE 3-2

Runs 159 to 457 - Thermal Conductance of Perspex With 30.5mm Holes (Experimental Conditions)

Runs	Specimens Nominal Thickness mm	Specimen Held Between Aluminium Plates		Approximate Mean Temperature °C	Voltage Setting Volts
		11a and 13a	11b and 13b		
159 - 171	11	5	6	50	35.4
172 - 184	11	5	6	36	17.0
185 - 197	11	5	6	60	44.6
198 - 210	11	6	5	50	35.4
211 - 223	11	7	8	50	35.4
224 - 236	11	8	7	50	35.4
237 - 249*	11	5	6	50	35.4
250 - 262*	11	5	6	36	17.0
263 - 275*	11	5	6	60	44.6
276 - 288*	11	6	5	50	35.4
289 - 301*	11	7	8	50	35.4
302 - 314*	11	8	7	50	35.4
315 - 327	5.6	3	4	50	35.4
328 - 340	5.6	3	4	36	17.0
341 - 353	5.6	3	4	60	44.6
354 - 366	5.6	4	3	50	35.4
367 - 379	5.6	1	2	50	35.4
380 - 392	5.6	2	1	50	35.4
393 - 405*	5.6	3	4	50	35.4
406 - 418*	5.6	3	4	60	44.6
419 - 431*	5.6	3	4	36	17.0
432 - 444*	5.6	4	3	50	35.4
445 - 457*	5.6	1	2	50	35.4

* - runs with aluminium foil inserts in the holes

TABLE 3-3

Runs 458 to 583 - Experimental Conditions

Runs	Specimens Nominal Thickness mm	Specimen Held Between Aluminium Plates		Approximate Mean Temperature ^{o}C	Voltage Setting Volts	Comments
		11a and 13a	11b and 13b			
458 - 470	19	13	14	55	50.0	Particle board conductivity determinations
471 - 483	19	14	13	55	50.0	Same comment as above, but specimens exchanged in guarded hot plate
484 - 496	19	9	10	55	50.0	Perspex conductivity determinations
497 - 509	19	9	10	45	35.4	Same comment as above, but at a lower temperature
510 - 522	19	10	9	55	50.0	Same as runs 484 - 496, but specimens exchanged in apparatus
523 - 535	19	13	14	55	50.0	Particle board with 35.5mm holes, conductance determinations
536 - 543	9.7	15	16	52	50.0	Syndanyo board conductivity determinations
544 - 548	9.7	15	16	110	132.0	Same comment as above, but at a higher temperature
549 - 555	11	5	6	45	35.4	Perspex with 35.5mm holes, conductance determinations
556 - 562	11	5	6	52	44.6	Same comment as above, but at a higher temperature
563 - 567	12.7	17	18	50	35.4	Polystyrene conductivity determinations
568 - 575	11	5	6	61	55.0	Perspex with 35.5mm holes, conductance determinations at $60^{o}C$
576 - 583	11	5	6	70	64.0	Same comment as above, but at a temperature close to the maximum working temperature

TABLE 3-4

Runs 584 to 664 - Thermal Conductivity and Conductance of Durotherm (Experimental Conditions)

Runs	Specimens Nominal Thickness mm	Specimen Held Between Aluminium Plates		Approximate Mean Temperature °C	Voltage Setting Volts	Comments
		11a and 13a	11b and 13b			
584 - 588	12	19	20	66	64	Runs 584 - 604: The determination of the thermal conductivity of durotherm at various voltage settings - hence various mean temperatures.
589 - 594	12	19	20	92	90	
595 - 598	12	19	20	130	120	
599 - 604	12	19	20	80	80	
605 - 610	12	19	20	69	64	Runs 605 - 634: The determination of the thermal conductance of durotherm with 34.925mm holes drilled. Mean temperatures close to those of runs 584 - 604.
611 - 616	12	19	20	84	80	
617 - 622	12	19	20	97	90	
623 - 628	12	19	20	137	120	
629 - 634	12	19	20	76	70	
635 - 640	12	19	20	78	64	Runs 635 - 664: The guarded hot plate apparatus was completely surrounded by fibreglass insulation in the box. Again durotherm with 34.925mm holes was used as the material at various mean temperatures.
641 - 646	12	19	20	86	70	
647 - 652	12	19	20	99	80	
653 - 658	12	19	20	114	90	
659 - 664	12	19	20	160	120	

TABLE 3-5

Runs 665 to 738 - Experimental Conditions

Runs	Specimens Nominal Thickness mm	Specimen Held Between Aluminium Plates		Approximate Mean Temperature °C	Voltage Setting Volts	Comments
		11a and 13a	11b and 13b			
665 - 669	11	21	22	45	35.4	Runs 665 - 678: 11mm long spacers separated the aluminium plates. The thermal conductance due to the entrapped air was measured at various temperatures.
670 - 674	11	21	22	50	44.6	
675 - 678	11	21	22	66	64.0	
679 - 684	11	5	6	45	35.4	Runs 679 - 702: 11mm thick perspex pieces with 40.5mm holes had their thermal conductances measured at various temperatures.
685 - 690	11	5	6	52	44.6	
691 - 696	11	5	6	61	55.0	
697 - 702	11	5	6	70	64.0	
703 - 708	19	11	12	45	35.4	Runs 703 - 720: Thermal conductivities of 19mm thick perspex pieces were determined at the three temperatures.
709 - 714	19	11	12	52	44.6	
715 - 720	19	11	12	61	56.0	
721 - 726	19	11	12	45	35.4	Runs 721 - 738: Oil was smeared on both faces of the 19mm thick perspex pieces. The thermal conductivities of the specimens were again determined at the same mean temperatures as in runs 703 to 720.
727 - 732	19	11	12	52	44.6	
733 - 738	19	11	12	61	56.0	

3.2 SCOPE OF THE THEORETICAL RESULTS

The results obtained in the experiments were used in the theoretical simulations. For example, run 172 was used to represent the results obtained for thermal conductance measurements of 11mm thick perspex pieces (5 and 6) with 30.5mm holes (runs 172 to 184). The experimental runs provided the following variables for the computer program:

(a) the boundary conditions - the hot and cold temperatures of the specimens

(b) the linear dimensions of the specimens - thicknesses and radii of the holes

(c) from (a), the thermal conductivities of the specimens (from runs 1 to 158) were known - the thermal conductivities of air at the mean temperatures were also known

The only variable that the experimental runs did not provide for the computer simulations, was the emissivity. The emissivity of perspex used in this work was experimentally measured by Dunkle R.V. in Australia (144). However, the emissivity of aluminium was unknown. To overcome this problem, all the computer simulations were performed using four different aluminium emissivities. The chosen emissivity values were 0.04, 0.11, 0.2 and 0.5.

The numbering system used for the computer simulation runs is:

If run number = 897X, then the simulation data used is based on experimental run 897. X denotes value of the aluminium emissivity used.

If X = A, then 0.04 was used

= B, then 0.11 was used

= C, then 0.2 was used

= D, then 0.5 was used

Table 3-6 shows the computer simulation runs. The letter after each simulation run number is omitted as in all cases the four aluminium emissivities were used.

TABLE 3-6

Results Used For Numerical Simulation Runs

Simulation Run	Temperature of Specimen Face		Thermal Conductivity in W/M°C		Comments
	Hot °C	Cold °C	Specimen	Air	
159	53.32	48.68	0.2053	.02784	11mm thick perspex specimens (plates 5 and 6) with 30.5mm holes at mean temperatures of 36, 50 and 60°C
172	36.48	35.67	0.2053	.02680	
186	61.76	56.25	0.2053	.02844	
201	51.99	48.25	0.2053	.02780	11mm thick perspex with 30.5mm holes at 50°C with specimen positions swapped
315	50.89	48.73	0.2000	.02779	5.6mm thick perspex specimens (plates 3 and 4) with 30.5mm holes at mean temperatures of 36, 50 and 60°C
331	36.36	35.82	0.2000	.02680	
341	61.78	58.37	0.2000	.02852	
549	47.67	43.41	0.2000	.02749	11mm thick perspex specimens (plates 5 and 6) with 35.5mm holes at mean temperatures of 42, 52, 61 and 70°C
556	56.27	49.64	0.2000	.02801	
568	66.20	56.10	0.2000	.02859	
576	76.68	63.25	0.2000	.02921	
605	77.07	60.94	0.2040	.02914	12mm thick durotherm specimens (plates 19 and 20) with 34.925mm holes at mean temperatures of 69, 84, 97 and 137°C
611	96.09	72.43	0.2040	.03020	
617	112.57	82.26	0.2040	.03110	
624	162.77	111.23	0.2040	.03371	
629	86.21	66.51	0.2040	.02966	
679	47.34	42.59	0.2000	.02744	11mm thick perspex specimens (plates 5 and 6) with 40.5mm holes at mean temperatures of 45, 52, 61 and 70°C
686	55.94	48.42	0.2000	.02796	
692	66.76	55.63	0.2000	.02859	
698	78.36	63.14	0.2000	.02926	

CHAPTER 4

QUANTITATIVE RESULTS

CHAPTER 4

QUANTITATIVE RESULTS

This chapter presents the results obtained from the developed experimental and theoretical solutions of the cavity problem.

4.1 EXPERIMENTAL RESULTS

Sample experimental results from each series of runs (Series B) are presented in this section. The complete set of results is presented in the Appendix.

4.1.1 THERMAL CONDUCTIVITY RESULTS

The measured thermal conductivities for the various materials are given below.

Table 4-1 shows the thermal conductivities of 5.6mm and 11mm thick perspex specimens (plates 1, 2, 3 and 4; and plates 5, 6, 7 and 8 respectively). The thermal conductivities are evaluated using the mean aluminium plate temperatures as described by equations 3-1 to 3-4 (see Appendix for sample calculation). As with all the other tables in this chapter, the specimen mentioned first was held between aluminium plates 11a and 13a; while the specimen mentioned last in each run was held between aluminium plates 11b and 13b (see Chapter 3). N.B. - later references to 'specimen position' refer to these alternative specimen positions.

The differences in the temperatures of the cold aluminium plates 11a and 11b, as previously mentioned (Chapter 2), are clearly shown in Table 4-1. For example, in run 2 the temperature of the cold aluminium plate 11a is 49.43°C, whereas that of plate 11b is 49.35°C. The temperature

TABLE 4-1

Thermal Conductivities of
5.6mm and 11mm Thick Perspex Plates

Experimental Run Number	Specimen Plate Number	Thickness of Specimen mm	Temperature of Specimen Surface Hot °C	Cold °C	Temperature Drop Across Specimen °C	Mean Specimen Temperature °C	Electrical Power Into Specimen W	Thermal Conductivity W/M°C
2	1	5.69	51.10	49.43	1.66	50.26	2.299	0.1968
	2	5.54	51.12	49.35	1.78	50.23	2.299	0.1792
16	3	5.66	51.27	49.61	1.66	50.44	2.297	0.1965
	4	5.64	51.29	49.45	1.84	50.37	2.297	0.1757
30	3	5.66	37.14	36.72	0.42	36.93	0.526	0.1789
	4	5.64	37.15	36.68	0.47	36.92	0.526	0.1583
44	3	5.66	61.61	59.07	2.546	60.34	3.651	0.2030
	4	5.64	61.62	58.58	3.035	60.1	2.651	0.1696
57	4	5.64	52.24	50.47	1.76	51.35	2.31	0.1846
	3	5.66	52.28	50.54	1.75	51.41	2.31	0.1872
70	2	5.54	52.01	50.25	1.75	51.13	2.303	0.1817
	1	5.69	52.04	50.34	1.70	51.19	2.303	0.1923
82	5	11.15	51.7	48.58	3.12	50.14	2.289	0.2045
	6	11.20	51.75	48.84	2.906	50.29	2.289	0.2205
95	5	11.15	36.84	36.12	0.72	36.48	0.528	0.2043
	6	11.2	36.85	36.16	0.69	36.51	0.528	0.2153
108	5	11.15	62.58	57.55	5.03	60.06	3.632	0.2015
	6	11.20	62.65	58.11	4.54	60.38	3.632	0.2239
121	6	11.20	52.55	49.64	2.91	51.09	2.284	0.2197
	5	11.15	52.54	49.28	3.26	50.91	2.284	0.1955
134	7	11.21	52.4	49.24	3.16	50.82	2.296	0.2038
	8	11.17	52.46	49.39	3.071	50.93	2.296	0.2088
147	8	11.17	51.94	48.75	3.20	50.34	2.303	0.2013
	7	11.21	51.99	48.9	3.08	50.45	2.303	0.2094

difference between the two plates is enough to cause a significant difference between the two resulting thermal conductivities of the specimens (0.1968 and 0.1792 W/M^{o}C).

In the Appendix the mean thermal conductivities and the corresponding standard deviations for each series of runs are worked out. Table 4-2 shows the means and standard deviations of the thermal conductivities of runs 1 to 158. The table also shows the resulting different thermal conductivities of the same specimens depending on the specimen position in the guarded hot plate. This effect was also observed for all the other runs using different specimens.

Table 4-3 shows the mean thermal conductivities measured for the other specimens used in the experiments. Among the results are those of perspex plates 11 and 12. In runs 703 to 720 the thermal conductivities of these two plates were found. At 61^{o}C, for example, the thermal conductivities measured were 0.2319 and 0.2270 W/M^{o}C respectively. The resulting thermal conductivities in runs 721 to 738 show the effect of having oil smeared on the perspex plates in an attempt to improve the thermal contact between the aluminium plates and the perspex specimens. At the same temperature of 61^{o}C, the conductivities are 0.2362 and 0.2261 W/M^{o}C. These conductivities are not significantly different from those obtained without oil on the plate surfaces. Consequently, the thermal contact resistance between the specimens and the aluminium plates was verified to be negligible. Runs 665 to 678 show the resulting conductances across the air spaces separating the aluminium

TABLE 4-2

Mean Thermal Conductivities of

5.6mm and 11mm thick perspex plates

Run	Specimen Plate Number	Thermal Conductivity W/M ^{o}C Mean	Std Deviation	Specimen Temperature ^{o}C Mean	Std Deviation
1 - 14	1	0.1934	.0019	50.40	.09
	2	0.1777	.0015	50.38	.10
69 - 80	2	0.1812	.0016	50.96	.14
	1	0.1946	.0018	51.03	.14
15 - 28	3	0.1965	.0011	50.48	.04
	4	0.1765	.0012	50.41	.03
56 - 68	4	0.1825	.0019	51.39	.15
	3	0.1856	.0022	51.44	.15
29 - 42	3	0.1942	.0172	36.55	.22
	4	0.1775	.0124	36.54	.23
43 - 55	3	0.2031	.0007	60.37	.05
	4	0.1730	.0013	60.16	.05
81 - 93	5	0.2053	.0021	50.26	.16
	6	0.2193	.0018	50.41	.15
120 - 132	6	0.2195	.0022	50.87	.21
	5	0.1953	.0028	50.69	.20
94 - 106	5	0.2010	.0042	36.51	.08
	6	0.2086	.0069	36.53	.08
107 - 119	5	0.2030	.0022	59.78	.34
	6	0.2232	.0018	60.08	.34
133 - 145	7	0.2053	.0016	50.67	.22
	8	0.2113	.0019	50.77	.22
146 - 158	8	0.2035	.0011	50.20	.13
	7	0.2123	.0021	50.30	.12

TABLE 4-3

Thermal Conductivities of

Miscellaneous Materials

Run	Specimen Plate Number	Material	Thermal Conductivity in W/M$^{\circ}$C at Specified Temperature				Comments
			45°C	52°C	55°C	Other	
484 - 509	9	Perspex	0.2203	-	0.2251	-	
	10	Perspex	0.2247	-	0.2247	-	
703 - 720	11	Perspex	0.2300	0.2301	-	0.2319 (61°C)	
	12	Perspex	0.2225	0.2240	-	0.2270 (61°C)	
721 - 738	11	Perspex	0.2328	0.2352	-	0.2362 (61°C)	Oil was smeared on both surfaces of the specimen - to determine the surface contact resistance
	12	Perspex	0.2202	0.2231	-	0.2261 (61°C)	
458 - 470	13	Particle Board	-	-	0.1663	-	
	14	Particle Board	-	-	0.1696	-	
536 - 548	15	Syndanyo Board	-	0.6947	-	0.8044 (110°C)	
	16	Syndanyo Board	-	0.6167	-	0.6881 (110°C)	
563 - 567	17	Polystyrene	-	-	-	0.0522 (49°C)	
	18	Polystyrene	-	-	-	0.0513 (49°C)	
584 - 604	19	Durotherm	0.2075 (66°C)	0.2093 (93°C)	0.2120 (130°C)	0.2033 (80°C)	
	20	Durotherm	0.1976 (66°C)	0.1998 (92°C)	0.2018 (130°C)	0.1956 (80°C)	
665 - 678	21	Air	0.0631	0.0669	-	0.0750 (66°C)	Spacers were used to separate the aluminium plates The values tabulated are conductance results.
	22	Air	0.0628	0.0664	-	0.0750 (66°C)	

plates. As mentioned in Chapter 3, spacers held the aluminium plates apart. The results shown in Table 4-3 are not true thermal conductivities of air since natural convection must have been occurring in the large stainless box enclosing the guarded hot plate. Radiative transfer between the aluminium plates also occurred.

From reference 146, the thermal conductivity of air is:

Temperature	Thermal Conductivity W/M°C
45°C	0.0276
52°C	0.0279
66°C	0.0290

4.1.2 THERMAL CONDUCTANCE RESULTS FOR SPECIMENS WITH 30.5mm HOLES

The measured thermal conductances for the 5.6mm and 11mm thick perspex specimens (plates 3, 4, 5 and 6) with 30.5mm holes are given below. The presented results (Table 4-4) are of the runs used in the computer simulations.

The thermal conductance evaluated is the effective conductivity as defined in Chapter 1 (1.5.1.1), that is, the sum of air conductance, solid conductance, and the radiation contribution in the holes.

4.1.3 THERMAL CONDUCTANCE RESULTS FOR SPECIMENS WITH ALUMINIUM FOIL IN THE HOLES

As described in Chapter 3, aluminium foil was used to divide the holes into two. (A single aluminium foil disc of slightly larger diameter than the hole was held using perspex glue at exactly half the specimen thickness in the

TABLE 4-4

Thermal Conductance Results For

Perspex Specimens With 30.5mm Holes

Experimental Run Number	Specimen Plate Number	Temperature of Specimen Surface Hot °C	Cold °C	Temperature Drop Across Specimen °C	Electrical Power Into Specimen W	Thermal Conductance W/M°C
159	5	52.32	48.47	3.65	2.294	0.175
	6	52.29	48.25	4.04	2.294	0.159
172	5	36.48	35.68	0.80	0.526	0.181
	6	36.50	35.60	0.90	0.526	0.162
186	5	61.75	56.24	5.51	3.620	0.183
	6	61.74	55.55	6.19	3.620	0.164
201	6	51.98	48.25	3.73	2.301	0.172
	5	52.00	48.04	3.96	2.301	0.162
315	3	50.89	48.74	2.15	2.289	0.150
	4	50.97	48.74	2.23	2.289	0.145
331	3	36.35	35.82	0.53	0.528	0.140
	4	36.39	35.84	0.55	0.528	0.136
341	3	61.78	58.38	3.40	3.630	0.151
	4	61.81	58.30	3.51	3.630	0.146

TABLE 4-5

Thermal Conductance Results For Perspex Specimens
With Aluminium Foil In The 30.5mm Holes

Experimental Run Number	Specimen Plate Number	Temperature Of Specimen Surface Hot °C	Cold °C	Temperature Drop Across Specimen °C	Electrical Power Into Specimen W	Thermal Conductance W/M°C.
237	5	51.60	47.92	3.68	2.296	0.174
	6	51.58	47.46	4.12	2.296	0.156
250	5	36.33	35.44	0.89	0.527	0.166
	6	36.33	35.38	0.95	0.527	0.155
263	5	61.87	56.09	5.78	3.64	0.176
	6	61.87	55.35	6.52	3.64	0.156
276	6	52.66	48.83	3.83	2.302	0.169
	5	52.65	48.42	4.23	2.302	0.152
289	7	52.26	48.23	4.03	2.288	0.159
	8	52.30	48.49	3.81	2.288	0.168
302	8	52.00	47.99	4.01	2.277	0.158
	7	52.04	48.34	3.70	2.277	0.173
393	3	51.10	48.86	2.24	2.296	0.145
	4	51.16	49.00	2.16	2.296	0.150
406	3	61.10	57.52	3.58	3.635	0.144
	4	61.21	57.82	3.39	3.635	0.151
419	3	36.66	36.09	0.57	0.524	0.131
	4	36.68	36.19	0.49	0.524	0.151
432	4	51.33	49.10	2.23	2.281	0.144
	3	51.35	49.21	2.14	2.281	0.151
445	1	50.58	48.63	1.95	2.284	0.166
	2	50.58	48.18	2.40	2.284	0.132

TABLE 4-6

Thermal Conductance Results For Specimens With 35.5mm Holes

Experimental Run Number	Specimen Plate Number	Temperature Of Specimen Surface Hot °C	Temperature Of Specimen Surface Cold °C	Temperature Drop Across Specimen °C	Electrical Power Into Specimen W	Thermal Conductance W/M°C
523	13	64.04	48.61	15.43	4.487	0.143
	14	64.05	49.14	14.92	4.487	0.148
549	5	47.66	43.42	4.25	2.292	0.150
	6	47.68	43.30	4.39	2.292	0.146
556	5	56.27	49.63	6.63	3.650	0.153
	6	56.29	49.38	6.91	3.650	0.148
568	5	66.13	56.17	9.97	5.548	0.155
	6	66.20	56.07	10.13	5.548	0.153
576	5	76.69	63.25	13.44	7.518	0.156
	6	76.78	63.29	13.49	7.518	0.156

TABLE 4-7

Thermal Conductance Results For Perspex Specimens With 40.5mm Holes

Experimental Run Number	Specimen Plate Number	Temperature Of Specimen Surface Hot ^{o}C	Temperature Of Specimen Surface Cold ^{o}C	Temperature Drop Across Specimen ^{o}C	Electrical Power Into Specimen W	Thermal Conductance $W/M^{o}C$
679	5	47.34	42.59	4.74	2.272	0.134
	6	47.34	42.48	4.86	2.272	0.131
686	5	55.94	48.42	7.51	3.633	0.135
	6	55.96	48.27	7.70	3.633	0.132
692	5	66.76	55.63	11.12	5.432	0.136
	6	66.80	55.45	11.35	5.432	0.134
698	5	78.36	63.14	15.22	7.600	0.139
	6	78.41	62.93	15.47	7.600	0.138

TABLE 4-8

Thermal Conductance Results For Durotherm Specimens With 34.925mm Holes

Experimental Run Number	Specimen Plate Number	Temperature Of Specimen Surface Hot °C	Temperature Of Specimen Surface Cold °C	Temperature Drop Across Specimen °C	Electrical Power Into Specimen W	Thermal Conductance W/M°C
605	19	77.07	60.94	16.12	7.691	0.144
	20	77.15	59.82	17.32	7.691	0.135
611	19	96.09	72.43	23.66	11.528	0.147
	20	96.23	71.01	25.22	11.528	0.138
617	19	112.57	82.26	30.29	14.928	0.149
	20	112.76	80.83	31.93	14.928	0.142
624	19	162.77	111.23	51.54	27.069	0.158
	20	163.13	109.73	53.41	27.069	0.154
629	19	86.21	66.51	19.70	9.226	0.141
	20	86.34	65.87	20.48	9.226	0.137
635	19	84.76	70.95	13.81	7.445	0.163
	20	84.79	68.54	16.24	7.445	0.139
641	19	94.39	77.72	16.67	9.146	0.166
	20	94.43	74.82	19.61	9.146	0.141
647	19	109.35	88.31	21.05	11.790	0.169
	20	109.41	84.75	24.65	11.790	0.145
653	19	126.61	100.49	26.11	14.910	0.172
	20	126.67	96.24	30.43	14.910	0.148
659	19	183.50	139.97	43.52	26.840	0.186
	20	183.63	133.65	49.98	26.840	0.163

hole - see Figure 2-12.) This was done only for runs using 5.6mm and 11mm thick perspex specimens with 30.5mm holes. Table 4-5 presents a sample of the results.

4.1.4 THERMAL CONDUCTANCE RESULTS FOR SPECIMENS WITH 35.5mm HOLES

Particle board specimens (plates 13 and 14) and 11mm thick perspex specimens (plates 5 and 6) had 35.5mm holes drilled in them. The measured thermal conductances are shown in Table 4-6.

4.1.5 THERMAL CONDUCTANCE RESULTS FOR SPECIMENS WITH 40.5mm HOLES

The thermal conductances of perspex plates 5 and 6 with 40.5mm holes are shown in Table 4-7.

4.1.6 THERMAL CONDUCTANCE RESULTS FOR DUROTHERM SPECIMENS

Table 4-8 shows the thermal conductances of durotherm with 34.925mm holes. The results in the run range 605 to 634 were obtained using polystyrene and air insulation in the stainless steel box. Those in the range 635 to 664 were obtained using fibreglass insulation.

4.1.7 QUANTITATIVE EXPERIMENTAL CURVES

Figures 4-1 to 4-3 summarise the above results and some associated data. They show the temperature differences across the specimens as functions of the heater wattage - the slopes being measures of conductances.

Figure 4-1 shows the effect of specimen thickness on the heat transfer rate for solid material and material with the same hole size (30.5mm diameter).

Figure 4-2 shows the effect of hole size on the same

FIGURE 4·1 HEAT FLUX Vs TEMPERATURE DROP

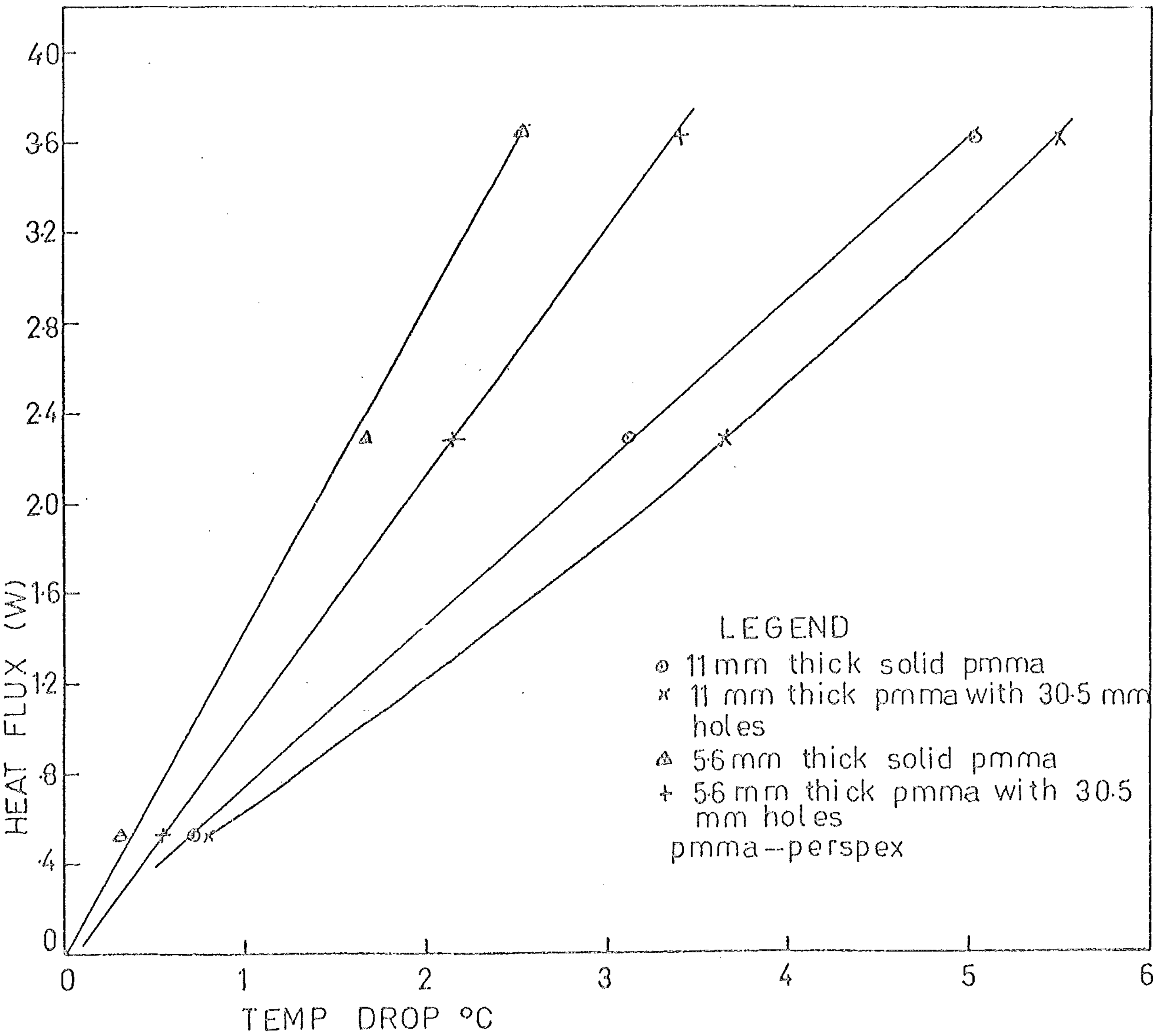


FIGURE 4-2 HEAT FLUX Vs TEMP DROP (11mm thick pmma various hole diameters)

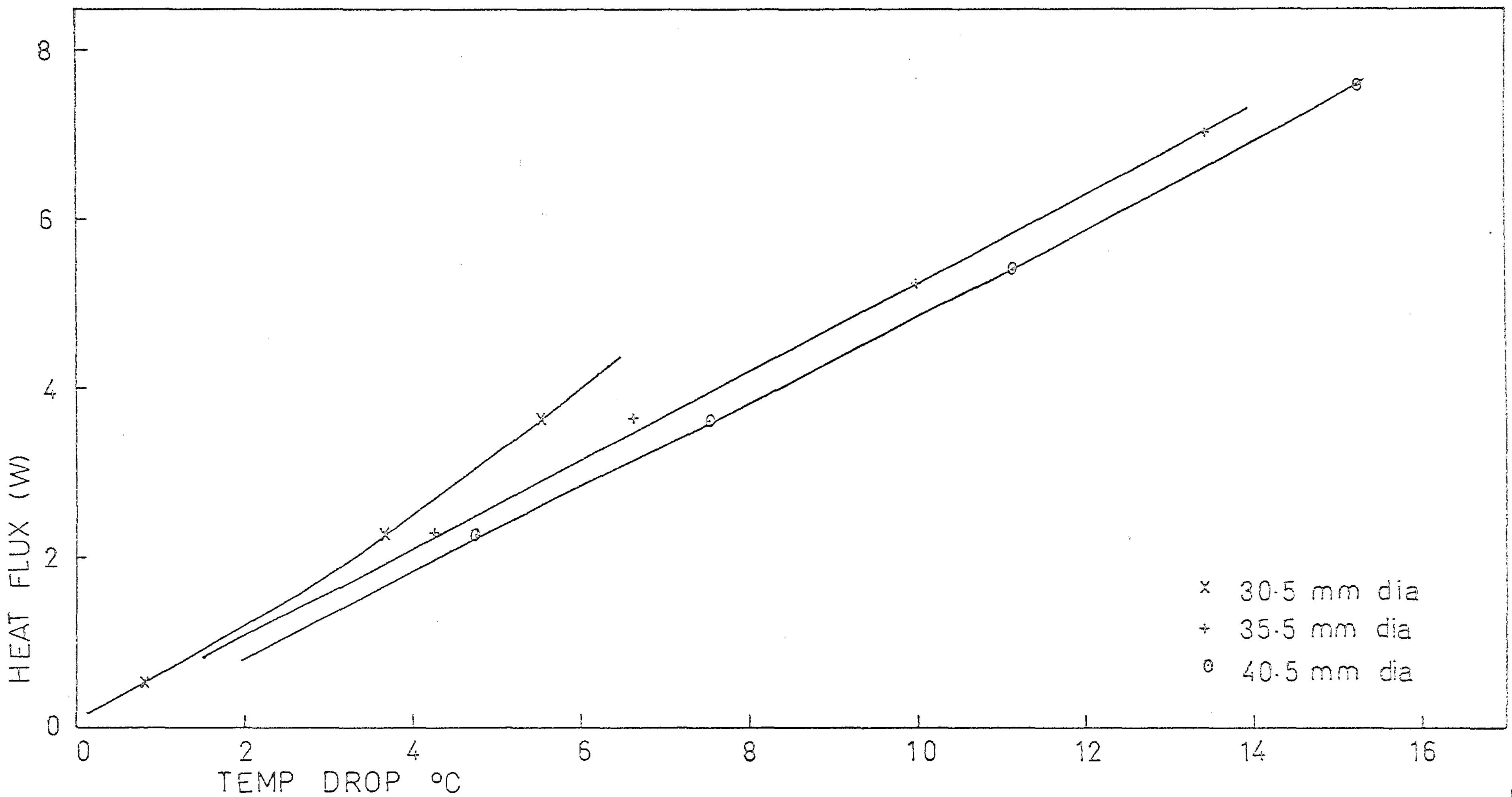


FIGURE 4-3 HEAT FLUX Vs TEMP DROP (durotherm)

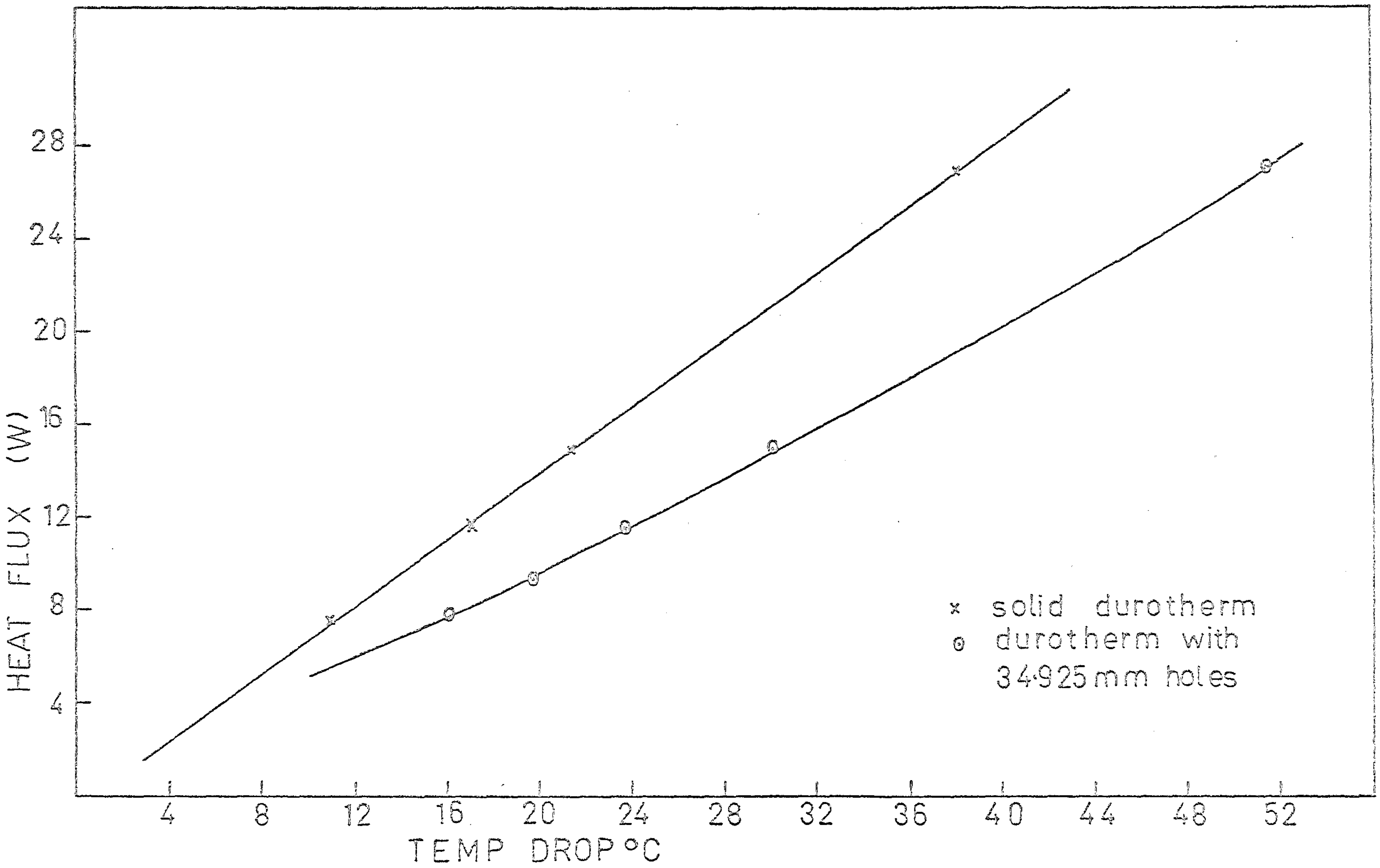


TABLE 4-9

Grashof And Rayleigh Numbers

Run	Gr	Ra
159	465	326
172	126	88
186	625	438
201	480	336
315	37	26
331	11	8
341	51	36
549	584	409
556	819	573
568	1113	779
576	1313	919
605	2052	1437
611	2470	1729
617	2692	1884
624	2886	2020
629	2275	1593
679	657	460
686	939	657
692	1226	858
698	1474	1032

specimen (plates 5 and 6).

Whereas the first two Figures used perspex specimens, the last Figure (Figure 4-3) used durotherm.

4.1.8 MISCELLANEOUS EXPERIMENTAL RESULTS

The Grashof and Rayleigh numbers associated with the experimental runs used in the theoretical simulations are evaluated in the Appendix. Table 4-9 presents them.

4.2 THEORETICAL RESULTS

Conduction heat flow in all directions varies from node to node. We know the conducted heat entering from the hot aluminium plate and leaving via the cold aluminium plate. Because of heat flow parallel to the aluminium plates, the total heat conducted perpendicular to the plates varies from layer to layer (Figures 4-6 and 4-7). We can define conduction heat flow across any plane parallel to the aluminium plates. The conduction heat flows tabulated and used in the diagrams are defined in each table and on each diagram.

Radiation can be defined as either the radiation leaving the hot end disc and touching cylinder or the radiation coming to the cold end disc and touching cylinder. The case used is defined for each Table and Figure. (Note that the sign convention used is that heat flow towards a nodal point is considered positive.)

The computed results of the simulation runs are presented in Table 4-10. They are:

(i) Heat transferred by solid conduction - this is the net heat flow crossing a given Z-X plane, perpendicular to the

TABLE 4-10

Results Of The Numerical Simulations

Run	Emissivity = 0.04 Heat Transferred (Watts)				Emissivity = 0.11 Heat Transferred (Watts)				Emissivity = 0.2 Heat Transferred (Watts)				Emissivity = 0.5 Heat Transferred (Watts)			
	Solid	Air	Radiation	Total	Solid	Air	Radiation	Total	Solid	Air	Radiation	Total	Solid	Air	Radiation	Total
159	1.761	0.175	0.0456	1.981	1.760	0.175	0.057	1.991	1.758	0.175	0.072	2.005	1.755	0.175	0.130	2.059
172	0.361	0.023	0.009	0.413	0.381	0.023	0.011	0.415	0.381	0.023	0.014	0.418	0.380	0.023	0.025	0.429
186	2.584	0.167	0.074	2.825	2.583	0.167	0.092	2.842	2.581	0.167	0.117	2.865	2.576	0.167	0.212	2.955
201	1.787	0.155	0.047	1.989	1.786	0.155	0.058	1.999	1.785	0.155	0.073	2.014	1.782	0.155	0.133	2.070
315	1.856	0.141	0.016	2.053	1.896	0.141	0.023	2.06	1.896	0.141	0.033	2.07	1.856	0.141	0.0716	2.108
331	0.476	0.028	0.004	0.507	0.476	0.028	0.005	0.508	0.476	0.028	0.007	0.510	0.475	0.028	0.016	0.519
341	2.961	0.176	0.028	3.185	2.981	0.176	0.04	3.197	2.980	0.176	0.057	- 3.214	2.980	0.176	0.124	3.28
549	1.637	0.169	0.061	1.867	1.636	0.169	0.078	1.883	1.635	0.169	0.102	1.906	1.632	0.169	0.193	1.993
556	2.647	0.426	0.102	3.175	2.645	0.426	0.131	3.202	2.642	0.426	0.170	3.239	2.635	0.426	0.322	3.383
568	3.942	0.532	0.167	4.641	3.939	0.532	0.214	4.685	3.936	0.532	0.279	4.746	3.925	0.532	0.528	4.985
576	5.222	0.607	0.242	6.071	5.218	0.607	0.310	6.134	5.213	0.606	0.402	6.221	5.196	0.606	0.761	6.563
605	5.978	0.605	0.3	6.883	5.971	0.605	0.378	6.954	5.964	0.604	0.482	7.05	5.939	0.603	0.886	7.429
611	6.799	0.921	0.503	10.223	8.787	0.921	0.632	10.340	8.772	0.920	0.808	10.5	8.727	0.918	1.484	11.128
617	11.311	1.217	0.718	13.245	11.29	1.216	0.903	13.41	11.267	1.215	1.155	13.636	11.197	1.212	2.121	14.53
624	19.44	2.253	1.656	23.350	19.38	2.25	2.087	23.718	19.312	2.247	2.672	24.230	19.122	2.237	4.913	26.272
629	7.313	0.753	0.391	8.457	7.304	0.752	0.492	8.548	7.293	0.752	0.628	8.673	7.259	0.750	1.154	9.164
679	1.401	0.210	0.080	1.69	1.4	0.21	0.105	1.715	1.399	0.21	0.139	1.749	1.40	0.21	0.274	1.880
686	2.393	0.719	0.135	3.247	2.390	0.719	0.178	3.288	2.387	0.719	0.237	3.343	2.378	0.719	0.466	3.563
692	3.472	0.899	0.217	4.589	3.468	0.899	0.286	4.654	3.464	0.899	0.381	4.743	3.450	0.898	0.749	5.098
698	4.672	0.994	0.324	5.991	4.666	0.994	0.427	6.087	4.659	0.994	0.567	6.220	4.638	0.993	1.116	6.747

plane. Unless otherwise indicated, in all the Tables and Figures presented in this chapter, the heat transferred by solid conduction is the sum of the heat flows in conduction zone C2 - Figure B1.

(ii) Heat transferred by air conduction - this is defined in exactly the same way as described above (i). Unless otherwise indicated, heat transferred by air conduction is the sum of the air heat flows in the hole in the 'air-conduction' region corresponding to solid conduction region C2. In Figures B7 and B8, the net heat flows associated with air nodal points 129, 131, 157 and 183; and surface nodal points 132, 145, 158, 171 and 184.

(iii) Heat transferred by radiation between the surfaces in the holes - this is the net radiative loss from the surfaces associated with the conduction region as described above. For example, if solid conduction region C2 is considered, the corresponding radiation regions are 1, 2 and half of 3 (Figure B6).

(iv) The total heat transferred by the above three methods.

The results are presented for the four emissivity values of aluminium chosen. In Appendix H, the heat flows of all the solid, air and radiation regions are presented (Run 568A).

4.2.1 TEMPERATURE AND HEAT FLUX PROFILES

The temperatures of the nodal points in conduction region C2 (Figure B1) are shown in Figure 4-4. The results used are those of numerical simulation run 692A (emissivity of aluminium = 0.04). Similarly, Figure 4-5 shows the

FIGURE 4-4

Temperatures of Conduction Region C2

Numerical Simulation Run 692A

62.965	62.977	62.998	63.020	63.033	63.040	63.043	63.045	63.045	63.046	63.047	63.047
62.955	62.969	62.993	63.018	63.032	63.039	63.043	63.045	63.045	63.046	63.047	
62.923	62.943	62.976	63.011	63.028	63.037	63.042	63.044	63.044	63.046		
62.859	62.893	62.943	62.977	63.021	63.033	63.039	63.041	63.041			
	62.868	62.927	62.991	63.018	63.032	63.038	63.041				
		62.861	62.967	63.005	63.025	63.034					
			62.884	62.970	63.009						
				62.878							

FIGURE 4-5

Temperatures of Conduction Region C3

Numerical Simulation Run 692A

59.335	59.333	59.331	59.331	59.333	59.335	59.336	59.336	59.336	59.337	59.337	59.337
59.339	59.336	59.333	59.332	59.333	59.334	59.336	59.336	59.336	59.337	59.337	
59.353	59.347	59.338	59.334	59.333	59.334	59.335	59.336	59.336	59.336		
59.384	59.37	59.351	59.338	59.335	59.335	59.335	59.335	59.335			
	59.383	59.358	59.34	59.335	59.335	59.335	59.335				
		59.389	59.349	59.338	59.335	59.335					
			59.387	59.35	59.338						
				59.39							

temperatures in conduction region C3. Using the temperature profile data in the Appendix, temperature profiles for the other runs could be similarly presented.

Since every nodal point had six 'conduction-rods' connected, six heat flows were associated with each point. With fifty eight nodal points in the solid, the heat flux profiles could not be fully presented. Figures 4-6 and 4-7 show some of the heat flows using run 692A results. Only Z and X direction heat flows are shown.

4.2.2 HEAT BALANCES

The heat balances of a few nodal points (run 698) are presented in Table 4-11. Every simulation run had the heat balances and the corresponding 'out-of-balance' error calculated. In all runs, the 'out-of-balance' error was less than 0.03% of the heat flow through the node.

4.2.3 RADIATIVE TRANSFER

The radiation flows shown in Table 4-10 are re-presented in Table 4-12.

The results of 11mm thick perspex plates with 35.5mm holes (runs 549, 556, 568 and 576) are graphically shown in Figure 4-8.

Using the emissivity value of aluminium of 0.11, the effect of the three hole sizes in the 11mm thick perspex specimens is shown in Figure 4-9.

4.2.4 TOTAL HEAT TRANSFERRED

The contributions of each mechanism of heat transfer in the cavity problem are shown in Figures 4-10 to 4-12.

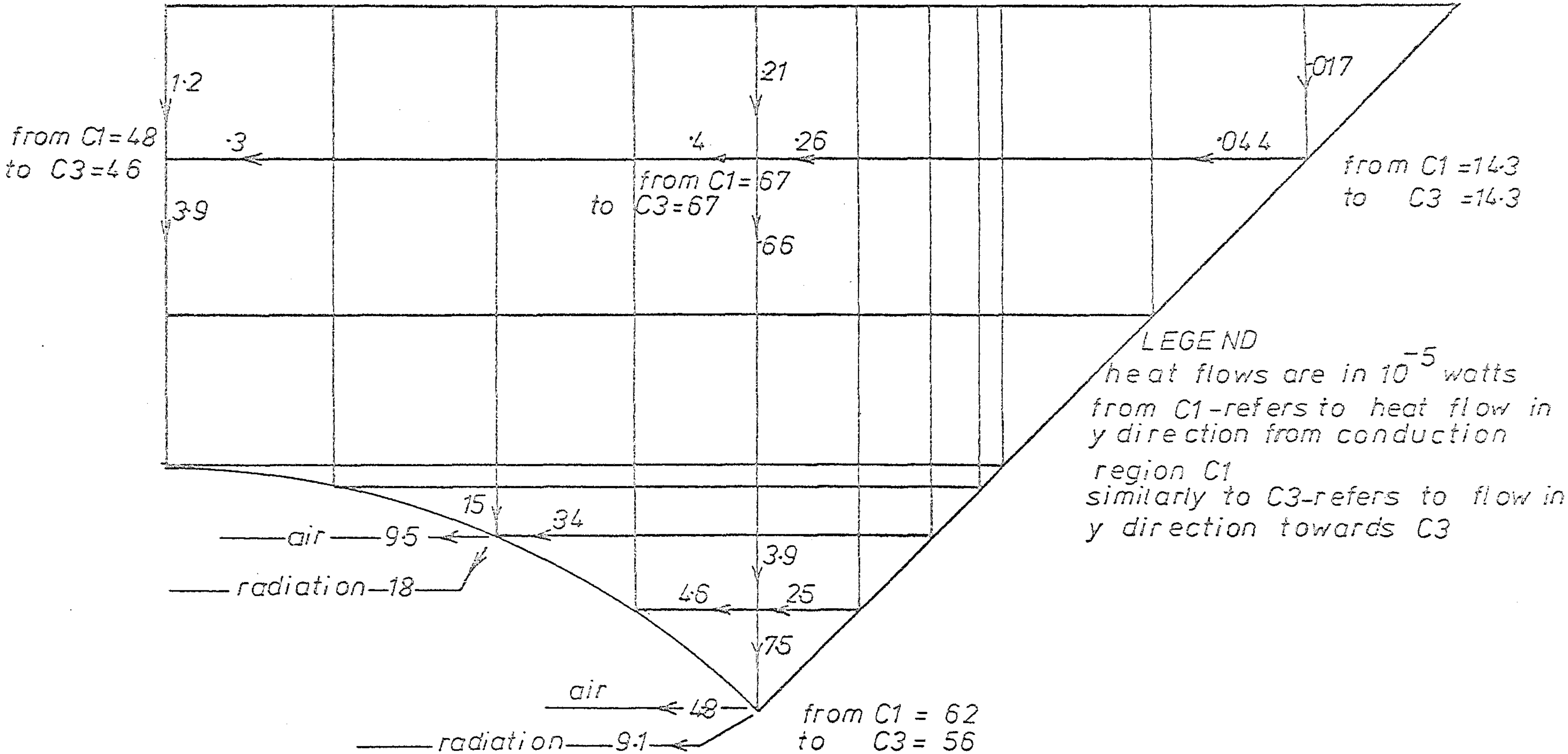


FIGURE 4-6 HEAT FLOWS FOR RUN 692A – CONDUCTION REGION C2

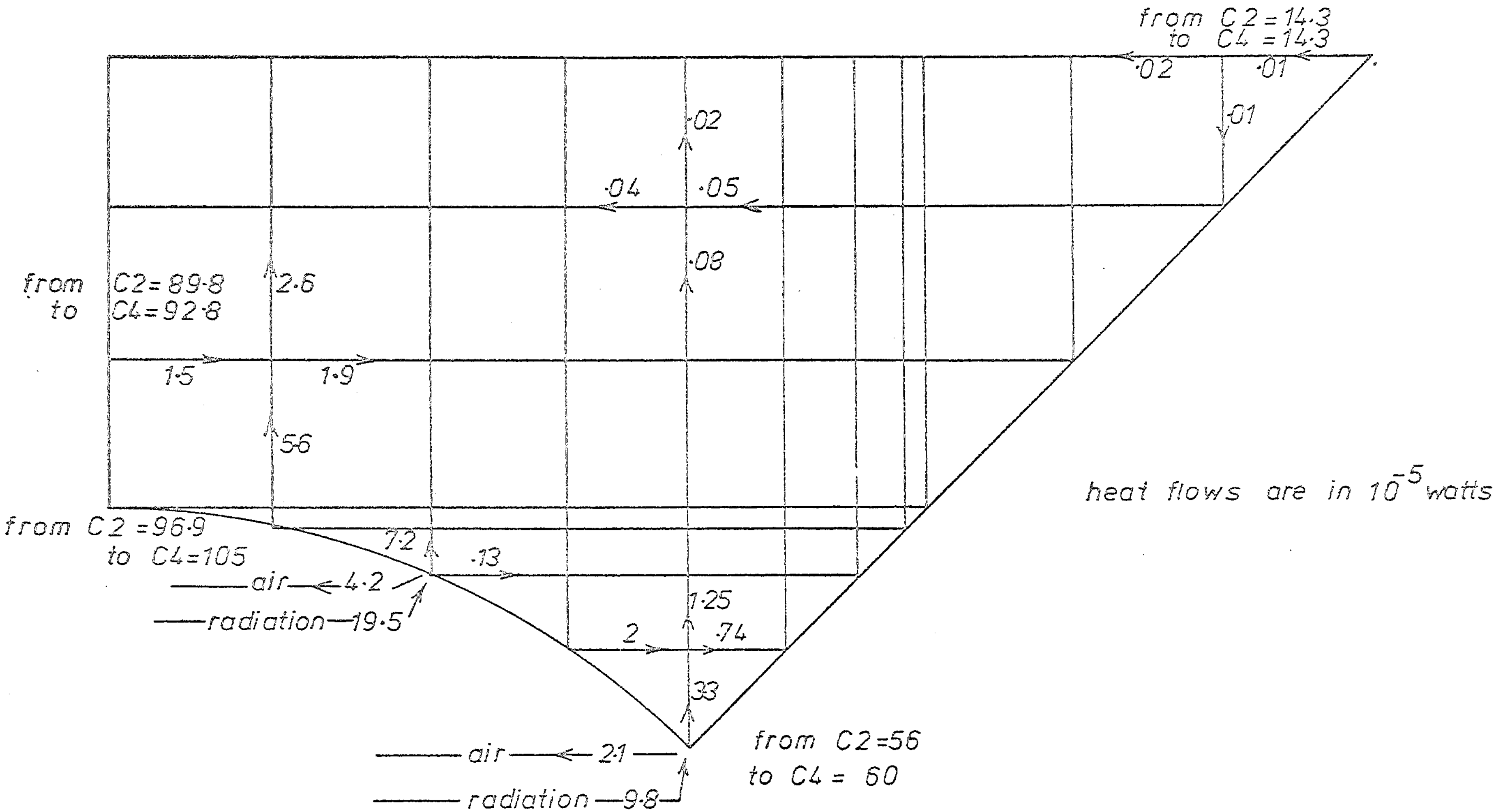


FIGURE 4·7 HEAT FLOWS FOR RUN 692A—CONDUCTION REGION C3

TABLE 4-11

Heat Balances

Nodal Point Number	Heat Into The Point (Watts)				Heat Conducted Away From Point (Watts)				% Error
	QYX(K+126)	QXY(K-1)	QZX(K-14)	Total	QYX(K)	QXY(K)	QZX(K)	Total	
129	-.535E-03	-.52E-05	0	-.54E-03	-.577E-03	.157E-04	.21E-04	-.54E-03	0
132	-.776E-03	-.23E-04+	-.136E-03*	-.935E-03	-.85E-03	-	.84E-04	-.935E-03	0
158	-.13E-02	-.46E-04+	-.27E-03*	-.167E-02	-.149E-02	-.37E-05	-.17E-03	-.167E-02	0
174	-.59E-03	-.53E-05	-.24E-04	-.615E-03	-.59E-03	-.319E-05	-.18E-04	-.615E-03	0.003
200	-.117E-02	-.819E-05	-.82E-04	-.126E-02	-.12E-02	-.90E-05	-.419E-04	-.126E-02	0

where: + - air conduction heat flows

* - radiation heat flows

$$\% \text{ Error} - \frac{(\text{Heat into point} - \text{Heat out of point}) \times 2 \times 100}{(\text{Heat into point} + \text{Heat out of point})}$$

K - nodal point counter

TABLE 4-12

Computed Radiation Heat Flows

Run	Temperature Drop Across Specimen °C	Radiation Heat Flow (Watts) For The Following Emissivities 0.04	0.11	0.2	0.5	Comments
159	3.65	0.046	0.057	0.072	0.130	11mm thick perspex plates (5 and 6) with 30.5mm holes
172	0.8	0.009	0.011	0.014	0.025	
186	5.51	0.074	0.092	0.117	0.212	
315	2.15	0.016	0.023	0.033	0.072	5.6mm thick perspex plates (3 and 4) with 30.5mm holes
331	0.53	0.004	0.005	0.007	0.016	
341	3.40	0.028	0.040	0.057	0.124	
549	4.25	0.061	0.078	0.102	0.193	11mm thick perspex plates (5 and 6) with 35.5mm holes
556	6.63	0.102	0.131	0.170	0.322	
568	9.97	0.167	0.214	0.279	0.528	
576	13.44	0.242	0.310	0.402	0.761	
605	16.12	0.300	0.378	0.482	0.886	12mm thick durotherm plates (19 and 20) with 34.925mm holes
611	23.66	0.503	0.632	0.808	1.484	
617	30.29	0.718	0.903	1.155	2.121	
624	51.54	1.656	2.087	2.672	4.913	
629	19.70	0.390	0.492	0.628	1.154	
679	4.74	0.080	0.105	0.139	0.274	11mm thick perspex plates (5 and 6) with 40.5mm holes
686	7.51	0.135	0.178	0.237	0.466	
692	11.12	0.217	0.286	0.381	0.749	
698	15.22	0.324	0.427	0.567	1.116	

FIGURE 4-8 RADIATIVE TRANSFER Vs TEMP DROP FOR VARIOUS EMISSIVITY (pmma with 35.5mm holes)

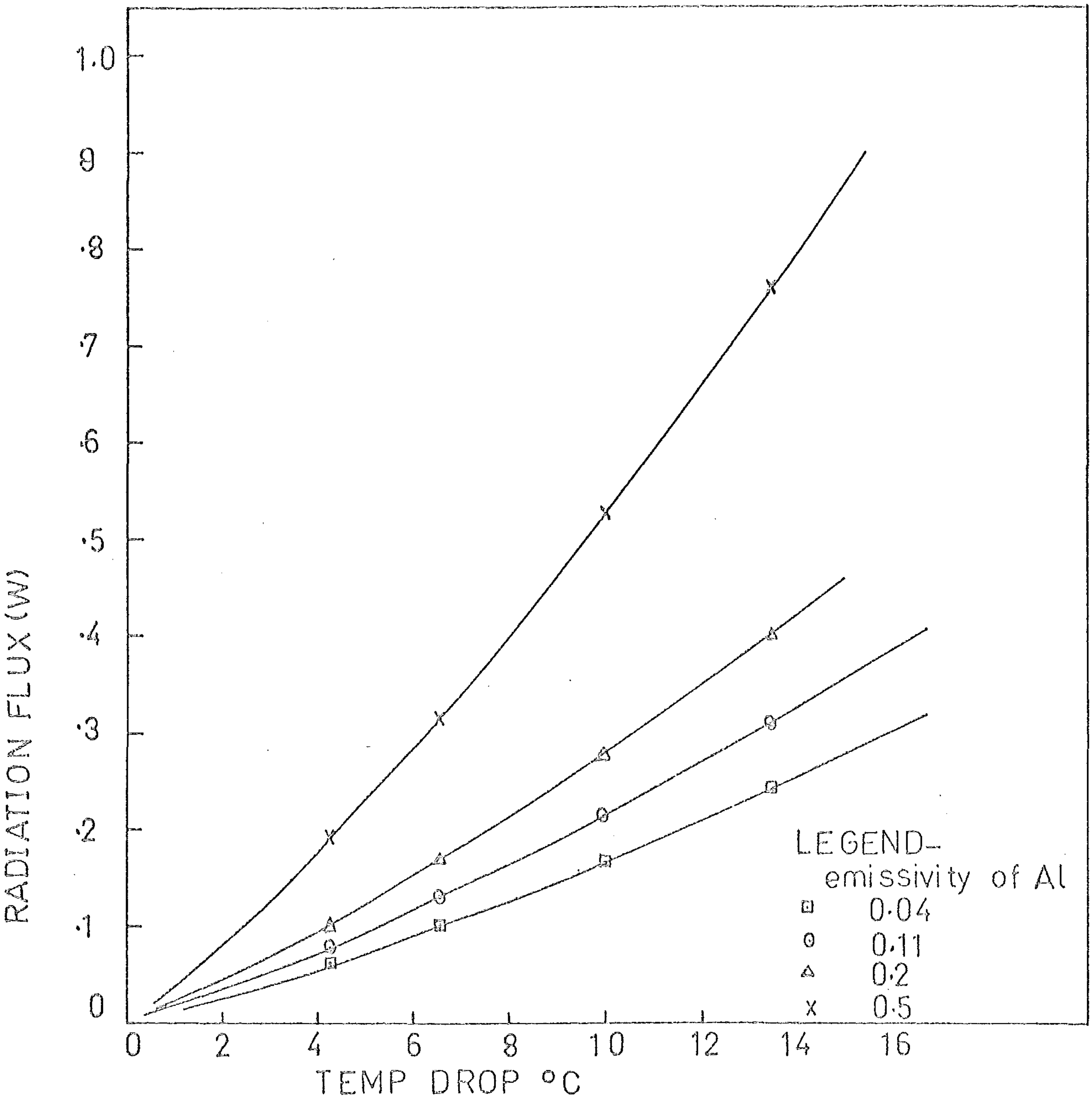
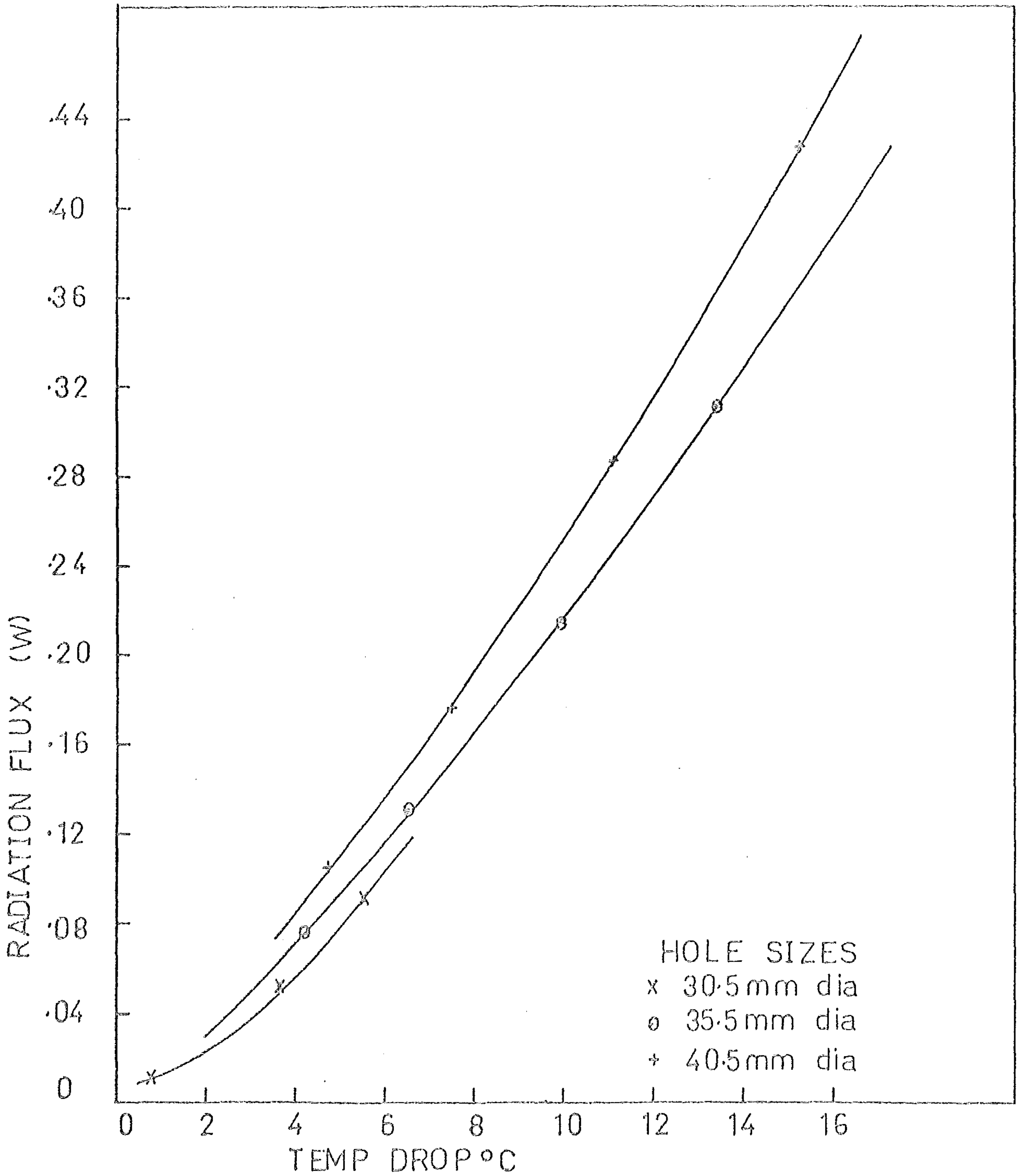


FIGURE 4·9 RADIATIVE TRANSFER Vs TEMP DROP FOR VARIOUS HOLE SIZES (11mm thick pmma with E_{Al} = 0·11)



(1) Figure 4-10: Using the results of the durotherm runs with an aluminium emissivity of 0.11, the heat flows are plotted against the temperature differences.

(2) Figure 4-11: Similar to Figure 4-10, but with 11mm thick perspex plates with 35.5mm holes used instead of durotherm plates.

(3) Figure 4-12: Using the results of 11mm thick perspex plates (run 576), the heat transferred is plotted against the emissivity.

4.3 COMPARISON OF EXPERIMENTAL AND THEORETICAL RESULTS

As previously mentioned (Chapter 1), to analyse the cavity problem fully, experimental measurements of gas conduction, solid conduction and radiation are required. The experimental procedure used did not measure any of these quantities individually. Consequently, the comparison with theoretical results is given in terms of the total heat transferred.

Table 4-13 compares the total heat transferred from the experimental runs with that computed from the numerical simulations using the four values of the emissivity of aluminium. The results obtained using 11mm thick perspex with 40.5mm holes are also shown graphically in Figure 4-13.

DISCREPANCIES BETWEEN THE THEORETICAL AND EXPERIMENTAL RESULTS

The difference between the theoretical and the experimental results is presented in Table 4-14 as an error percentage.

$$\text{error percentage} = \frac{(Q_{\text{experimental}} - Q_{\text{theoretical}}) \times 100}{Q_{\text{experimental}}} \tag{4-1}$$

FIGURE 4-10 THE CONTRIBUTION OF EACH MECHANISM OF HEAT TRANSFER (durotherm)

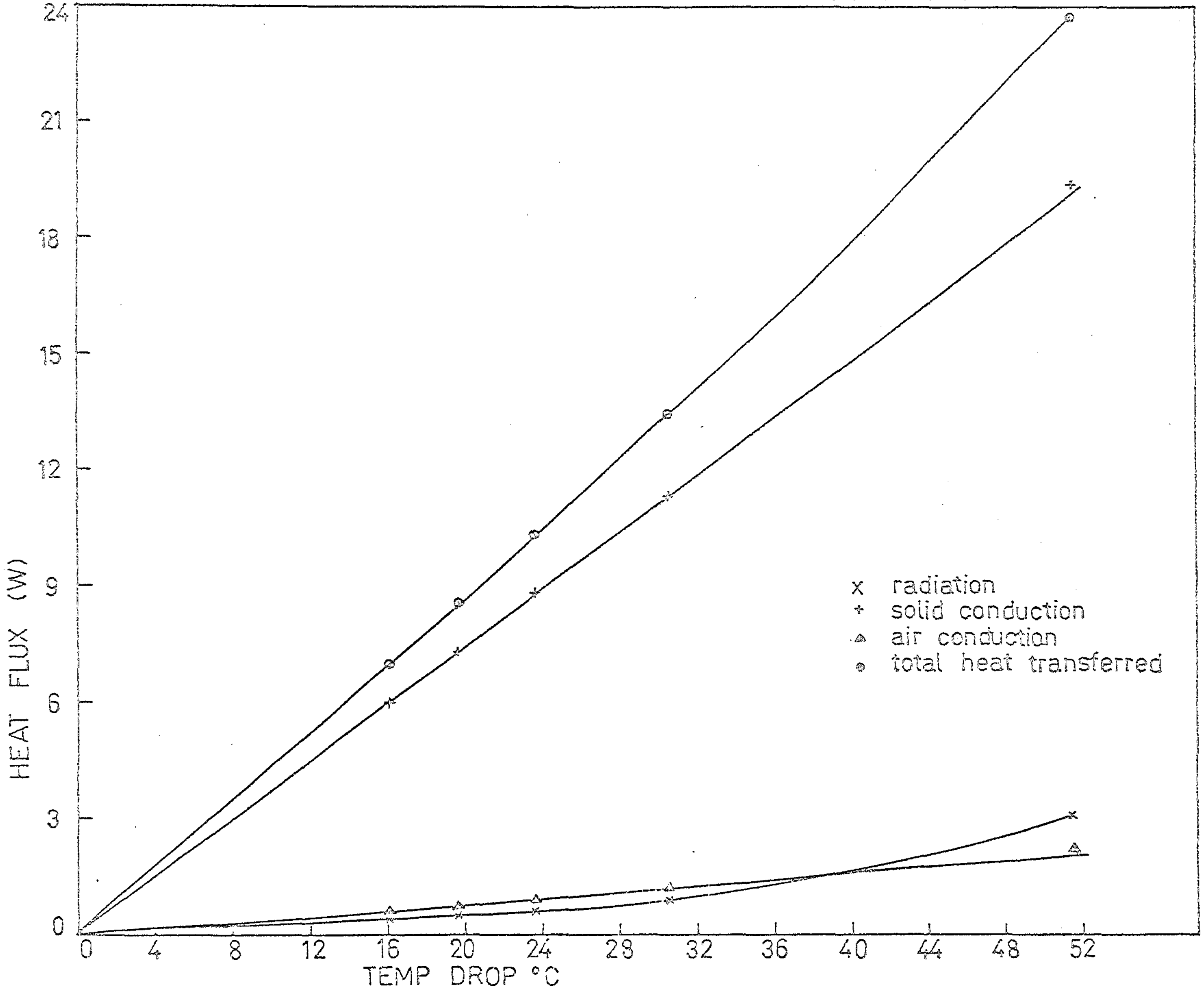


FIGURE 4-11 THE CONTRIBUTION OF EACH MECHANISM OF HEAT TRANSFER IN PMMA WITH 35·5mm HOLES (E_{Al} = 0·11)

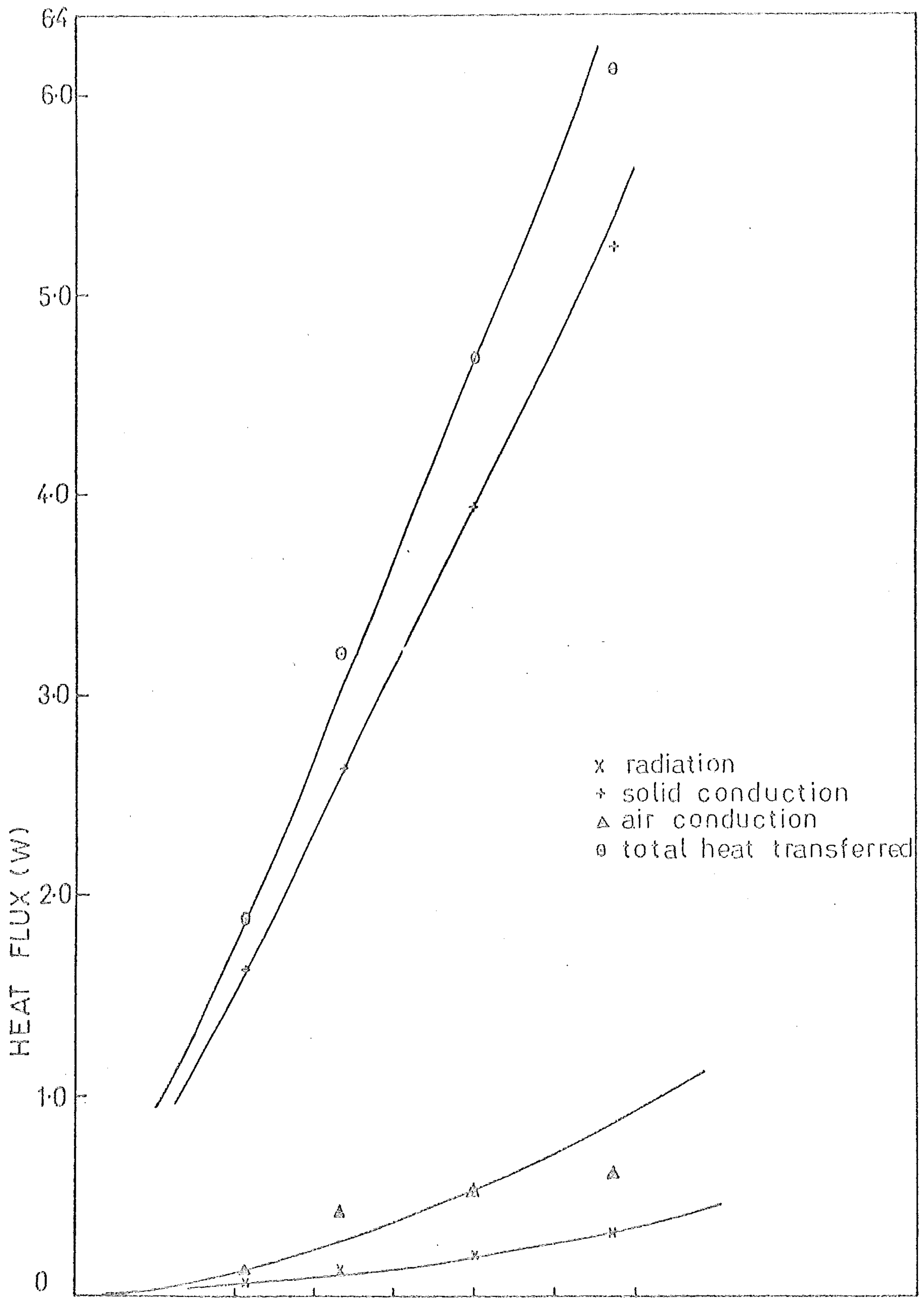


FIGURE 4·12 THE EFFECT OF EMISSIVITY (pmma with 35·5mm holes)

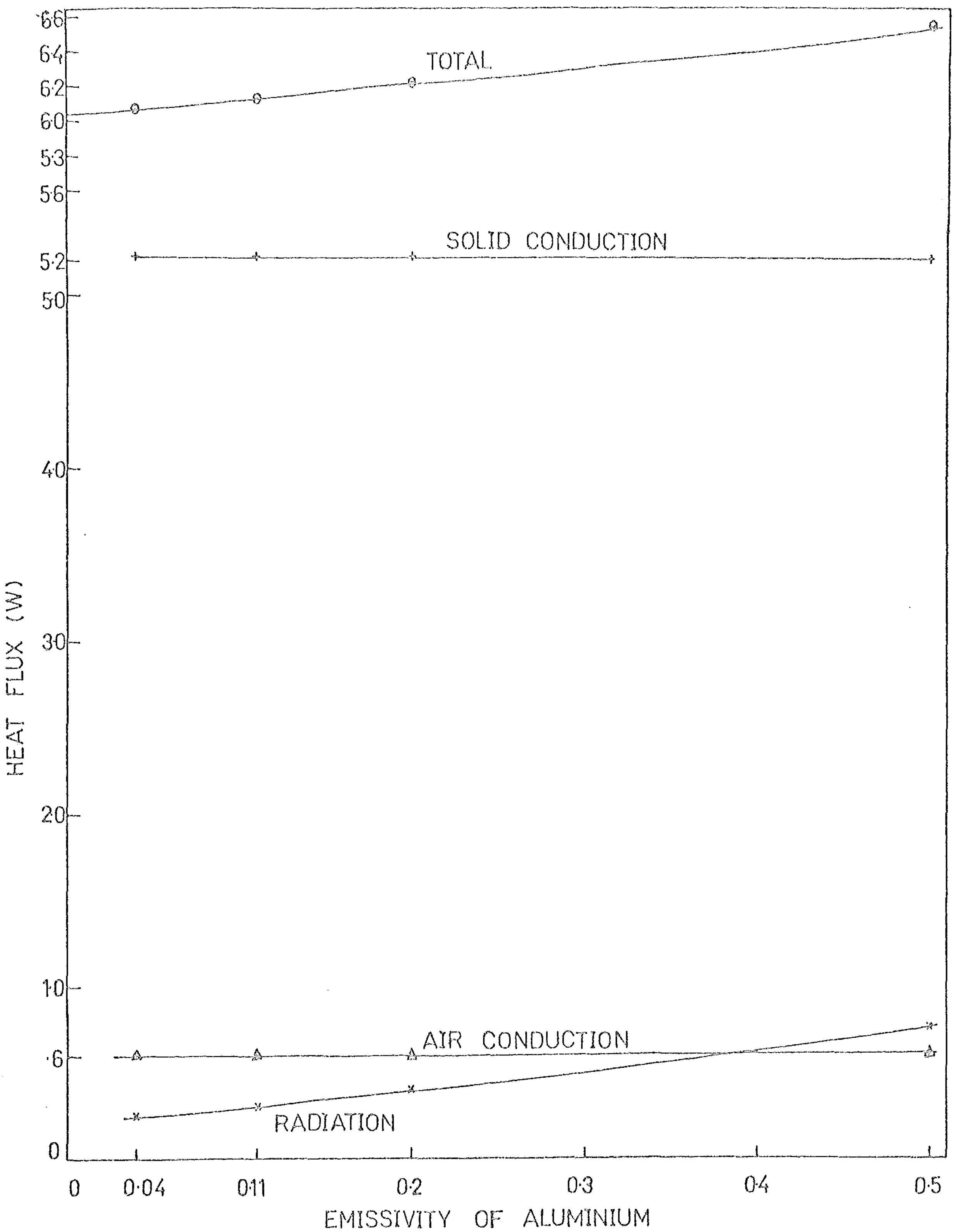


TABLE 4-13

The Total Heat Transferred - Experimental and Theoretical For Various Values Of Aluminium Emissivity

Run	Total Heat Transferred (Watts): Experimental	Computed From Numerical Simulations For Emissivities Of Aluminium Of: 0.04	0.11	0.2	0.5	Comments
159	2.294	1.981	1.991	2.005	2.059	11mm thick perspex plates with 30.5mm holes
172	0.526	0.413	0.415	0.418	0.429	
186	3.62	2.825	2.842	2.865	2.995	
201	2.301	1.989	1.999	2.014	2.070	As above with perspex plates swapped
315	2.289	2.053	2.060	2.070	2.108	5.6mm thick perspex plates with 30.5mm holes
331	0.528	0.507	0.508	0.510	0.519	
341	3.63	3.185	3.197	3.214	3.280	
549	2.292	1.867	1.883	1.906	1.993	11mm thick perspex plates with 35.5mm holes
556	3.65	3.175	3.202	3.239	3.383	
568	5.548	4.641	4.685	4.746	4.985	
576	7.518	6.071	6.134	6.221	6.563	
605	7.691	6.883	6.954	7.050	7.429	12mm thick durotherm plates with 34.925mm holes
611	11.528	10.223	10.340	10.500	11.128	
617	14.928	13.245	13.410	13.636	14.530	
624	27.069	23.350	23.718	24.230	26.272	
629	9.226	8.457	8.548	8.673	9.164	
679	2.272	1.690	1.715	1.749	1.880	11mm thick perspex plates with 40.5mm holes
686	3.633	3.247	3.288	3.343	3.563	
692	5.432	4.589	4.654	4.743	5.098	
698	7.6	5.991	6.087	6.220	6.747	

FIGURE 4.13 TOTAL HEAT TRANSFERRED-EXPERIMENTAL Vs THEORETICAL (11 mm thick pmma with 40.5 mm holes)

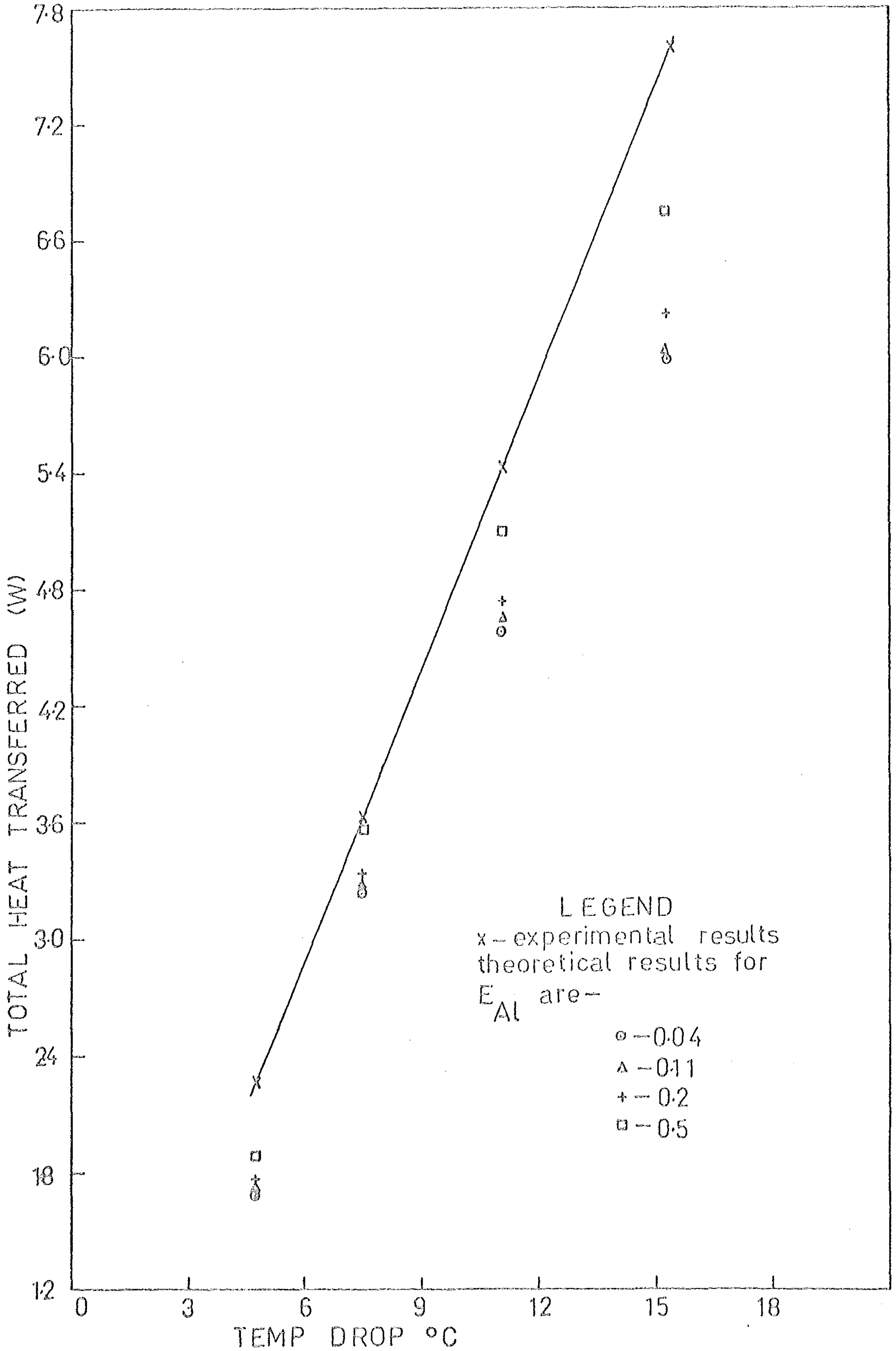


TABLE 4-14

The Discrepancies Between The Theoretical And The Experimental Results

Run	Error Percentage Between Theoretical And Experimental Total Heat Flows — Emissivity Of Aluminium 0.04	0.11	0.2	0.5	Comments
159	13.64	13.21	12.60	10.24	11mm thick perspex plates with 30.5mm holes
172	21.48	21.10	20.53	18.44	
186	21.96	21.49	20.86	18.37	
201	13.56	13.12	12.47	10.04	
315	10.31	10.00	9.57	7.90	5.6mm thick perspex plates with 30.5mm holes
331	3.98	3.78	3.41	1.70	
341	12.60	11.93	11.46	9.64	
549	18.54	17.84	16.84	13.05	11mm thick perspex plates with 35.5mm holes
556	13.01	12.27	11.26	7.32	
568	16.35	15.56	14.46	10.15	
576	19.25	18.41	17.25	12.70	
605	10.51	9.58	8.33	3.41	12mm thick durotherm plates with 34.925mm holes
611	11.32	10.31	8.92	3.47	
617	11.27	10.17	8.65	2.67	
624	13.74	12.38	10.49	2.94	
629	8.34	7.35	5.99	0.67	
679	25.62	24.52	23.02	17.25	11mm thick perspex plates with 40.5mm holes
686	10.62	9.50	7.98	1.93	
692	15.52	14.32	12.68	6.15	
698	21.17	19.91	18.16	11.22	

CHAPTER 5

DISCUSSION

CHAPTER 5

DISCUSSION

5.1 DISCUSSION OF THE APPARATUS

It has not been possible with the equipment (designed and built) to do full justice to the cavity problem. For example, gas conduction, solid conduction and radiation have not been measured experimentally. The cavity problem encompasses many materials in a wide range of practical conditions (for example temperatures and thicknesses). Many factors (section 1.3) can influence both the material and the results obtained.

5.1.1 REFERENCE MATERIALS

In work devoted to thermal conductivity (and/or conductance) measurements, some guide to the accuracy of the method can be obtained by the comparison of results obtained on reference materials. One of the difficulties for the case of the guarded hot plate method concerns the absence of suitable materials. The only ones which can be regarded as true reference materials are a pure gum rubber, a cork board, and a fibrous glass material of two different densities (6). All these have a limited temperature range of use. Rubber was used in trial runs (Chapter 3), but was found to be unsuitable due to the uncertainties in its thickness, homegeneity and thermal creep behaviour (143). Cork board was also used and rejected as its structure was not stable - (a) the moisture content varied with temperature, (b) the glue used to hold the wood particles together decomposed on heating, and (c) cork board is not homogeneous.

A suitable material to be used with the equipment designed in this work needs to be:

(a) an opaque insulator with a thermal conductivity of about 0.03 W/M^{o}C

(b) machineable

(c) homogeneous

Perspex was used in this work because it is:

- homogeneous
- machineable
- available locally in varying thicknesses

Perspex has a limited temperature range (maximum service temperature is 80^{o}C). It is also partially transparent to radiation in the wavelength range 0.3 to 1.6 microns. The radiation transfer in this range was checked approximately (Appendix) and found to be negligible. Durotherm, which is opaque, was also used to check the validity of the developed experimental and numerical methods (at temperatures higher than 80^{o}C, up to 160^{o}C).

Other materials considered were:

- teflon which is very expensive ($1500 for the specimen sizes used in this work)
- phenol formaldehyde (bakelite)which is not available locally
- Triton's kaowool and ICI's saffil aluminium fibre will become available next year

5.1.2 GUARDED HOT PLATE

The apparatus built in this work is the low temperature guarded hot plate. The maximum operating temperature is 600^{o}K. Provided a suitable material can be found, it is possible to operate the apparatus at temperatures greater than 473^{o}K (where radiation is significant (47,48,60)).

From the nine thermocouple wires on each isothermal aluminium plate, the one dimensional heat flow assumption was verified. The standard deviation of the thermocouple outputs on any plate was less than 0.001 millivolts. This corresponds to a probable error percentage of 0.02.

The power into the guarded hot plate was evaluated from the product of the voltage and current. The voltage and the current were measured to a high degree of accuracy (0.005%). The actual power dissipated through the specimens was assumed to be half the electrical power since two specimens were present (Chapter 1). There was no way of checking this assumption experimentally other than by comparing the temperatures of the two cold aluminium plates (and also the two hot aluminium plates). Other workers (30,44) used cooling coils in the cold aluminium plates and measured the heat gained by the cooling water. The use of cooling coils in the cold aluminium plates makes the guarded hot plate bulky and not so easy to dismantle and assemble. However, in order that the heat transferred by the specimens be known accurately, cooling coils are essential (Chapter 7).

The enclosure surrounding the guarded hot plate is important (49). The results of experimental runs Series 'A' (when plastic bags were used to enclose the apparatus) verify this. Steady-state was attained in three hours or less. With the stainless steel enclosure (Series 'B'), steady-state was attained after thirty six hours. From Table E1 (Series 'A' results), the temperature drop across perspex specimen 'CA' is 1.6°C, whereas that across specimen 'CB' is 1.67°C. The difference between these two temperature drops is 0.07°C (a systematic error percentage of 4.3). For a typical Series 'B' experimental run, the mean temperature drop across perspex plate 1 is 1.66°C, and that across perspex plate 2 is 1.78°C. The difference between these two temperature drops is 0.12°C (a systematic error percentage of 7). Hence, although the perspex plates ('CA' and 'CB') of Series 'A' experiments were unmachined, they still gave better results than Series 'B' experiments (with the machined perspex plates). It seems likely that Series 'A' experiments gave better results because of the absence of the insulation resistance in the region of the cold aluminium plates because plastic bags were used instead of the stainless enclosure (see below). The hydrostatic pressure forced all the air out of the plastic bags and the aluminium plates were surrounded by the constant temperature water. In the stainless steel enclosure (used in Series 'B' experiments), insulation was put inside (Figure 2-5) and the thermocouple wire outlet tube blocked by cotton wool. A substantial amount of air remained in the box. Consequently, the insulation resistance in the stainless box contributed to the accuracy of the results obtained. As previously mentioned (Chapter 3), plastic bags were not used in Series 'B' experiments because they tore easily and hence leaked during runs.

The importance of the insulation used in the stainless box is illustrated by some of the durotherm runs. In runs 635 to 664, the guarded hot plate was completely surrounded by fibreglass insulation. Using the same temperature drops (voltage settings) as in runs 605 to 634, the thermal conductances were measured. Consider for example the results of runs 611 and 647 (the former run used the polystyrene-air insulation system of Figure 2-5, while the latter run used fibreglass insulation).

(A) Run 611 - The thermal conductance of durotherm plate 19 = 0.147 W/M^{o}C at a temperature drop of 23.66^{o}C. The conductance of plate 20 = 0.138 W/M^{o}C at a temperature drop of 25.22^{o}C.

(B) Run 647 - The thermal conductance of durotherm plate 19 = 0.169 W/M^{o}C at a temperature drop of 21^{o}C and the conductance of plate 20 = 0.145 W/M^{o}C at a temperature drop of 24.65^{o}C.

Assuming that the discrepancy between the 'temperature-drops' across the specimens on either side of the heater is due to different heat flows through each specimen, the mean temperature drop should be used to work out the conductance. The causes of this discrepancy were discussed preliminarily in Chapter 2 in the description of the 'positioning arrangement' experiments. It was observed that the temperature of cold plate 11a was always greater than that of cold plate 11b. This statement is true for runs I to VI in Chapter 2, however, in general it is not true. In runs 432 to 444, the reverse is true. For example, in run 432, the temperature of cold plate 11a is 49.1^{o}C, whereas that of aluminium cold plate 11b is 49.21^{o}C. Similarly, in runs 289 to 314, the temperature of cold aluminium plate 11b is greater than that of cold aluminium plate 11a. Various other series of runs in the range 1 to 738 can be found in which the temperature of plate 11b is greater than that of plate 11a. From these observations and those outlined in Chapter 2, the difference in the 'temperature-drops' across the specimens was termed the systematic error of the experiment (with a magnitude of 10% (Appendix)). The causes of the systematic error were:

(a) Arrangement of the guarded hot plate in the box - since the insulation inside the box contributed substantially to the heat transfer, any slight changes in the exact positioning of the apparatus caused one cold aluminium plate to have a different external resistance from that of the other side. Orr (49) found it necessary to control the ambient temperature in the box by stirring the air with a large diameter fan at low speed and keeping the box close to the mean specimen temperature.

(b) Arrangement of the plates - in assembling the guarded hot plate, it was practically impossible to align the plates in exactly the same positions relative to one another. Set squares and right-angled steel sections were used in trying to align the plates in the same positions.

GENERAL REMARKS - GUARDED HOT PLATE:

(1) Fluctuations in the power supply could not be eliminated despite the use of two stage voltage regulation (Figure 2-2). The resulting process error was 0.04% (Appendix).

(2) The constant pressure on the plates (for good thermal contact) was implemented by the use of stainless steel studs and 'cross-bar' supports (Figure 2-3).

(3) The emissivity of the aluminium surfaces in the apparatus was not known accurately.*

5.1.3 MEASURING INSTRUMENTS

(1) Thermocouple outputs - these were measured using a potentiometer. The uncertainty in the potentiometer readings was 2 microvolts. The monitoring of the millivolt signals was a slow process (and very demanding in human endurance). More readings would have been obtained had an accurate digital potentiometer been available (for example, Honeywell, Model 40011-20). The uncertainty in the calibration of thermocouple wires was $0.04^{\circ}C$ (Chapter 2). Considering a surface temperature of $45^{\circ}C$, the uncertainty in the indicated temperature was $0.02^{\circ}C$ (Chapter 1).

(2) Power input - due to the accuracy of the digital multimeters used, the uncertainty in the product of the voltage and the current was 0.01%.

(3) Waterbath - the thermostatic bath was kept at $31.0 \pm 0.1^{\circ}C$.

(4) Plates - the aluminium plates and all the specimens were machined to ± 0.03mm. Considering perspex plate 5 for example, the error due to its non-flatness was 0.3%.

* Preliminary measurements were made by Dr J.B. Stott of the Chemical Engineering Department, University of Canterbury. The radiation emitted by a plane aluminium surface similar to those used in the conductance experiments was compared with the radiation from a similar soot blackened surface using a 'Moll' thermopile over the temperature range 25° to $90^{\circ}C$. These experiments gave an emissivity of 0.08.

5.2 DISCUSSION OF EXPERIMENTAL RESULTS

The curves and tables of Chapter 4 and the Appendix summarise the results of the experimental investigations reported in this work.

5.2.1 DISCUSSION OF THERMAL CONDUCTIVITY RESULTS

The basis of the thermal conductivity evaluations is the Fourier equation (1-1). The uncertainties in the variables q, A, dT and dx all contribute to the uncertainty in the value of K. As previously discussed, the largest source of error is the systematic error (difference in the temperature drops across the specimens) (systematic error is equal to 10%). The other variables (A, q, dx - process and measurement errors) contribute 2% to the experimental error (Appendix) making the total experimental error 12%.

The reliability of the apparatus is in its ability to reproduce the thermal conductivity of a given material at the same settings. The A.S.T.M. Standard (5) requires that the thermal conductivity be reproduced to within 1% from four consecutive readings every half hour. From Table 4-2, the thermal conductivities of 5.6mm and 11mm thick perspex plates are reproduced to within 1%. (For example, in runs 1 to 14, the mean thermal conductivity of plate 1 was .1934 W/M^{o}C, with a standard deviation of .002.) The exceptions were runs performed at mean specimen temperatures of 36^{o}C. The thermal conductivities for these runs were reproduced to within 9% (for example, runs 29 to 42). This large discrepancy was caused by the small temperature drops across the perspex specimens. For example, in run 30 the temperature drop across perspex plate number 4 was 0.5^{o}C.

In the Appendix, Table F2 shows the mean thermal conductivities of the perspex plates 1 to 8, that is, the means of the temperature drops on both sides of heater have been used. For example, considering plate 1, the thermal conductivity was evaluated as the mean of results of runs 1 to 14, and those of runs 69 to 80. The value obtained was 0.194 $W/M^{o}C$ with a standard deviation of 0.0008. An estimate of the discrepancy in the determined thermal conductivity was 0.41%. For 11mm thick perspex plate 5, the discrepancy was found to be 3.5% (this was the worst discrepancy - Table F2). The determined thermal conductivities of perspex are in agreement with the literature values - 0.188 $W/M^{o}C$ (145) and (146).

The observations mentioned above also apply to the other materials used in this work. For example, the thermal conductivity of durotherm plate number 19 at $66^{o}C$ is 0.2075 $W/M^{o}C$ with a standard deviation of 0.0006. Hence, the thermal conductivity of durotherm was determined to within 1%. The results of the thermal conductivities of 19mm thick perspex, particle board, syndanyo board, polystyrene and durotherm are in Table 4-3. Syndanyo board results show a large discrepancy at high temperatures (thermal conductivity of plate 15 is 0.80 $W/M^{o}C$, while that of plate 16 is 0.69 $W/M^{o}C$ at $110^{o}C$). Consequently, syndanyo board was not used in the experiments with holes drilled.

5.2.2 DISCUSSION OF THERMAL CONDUCTANCE RESULTS

The difference in the 'temperature-drops' across the specimens is evident in most results. For example, from Table 4-4, run 159, the temperature drop across perspex plate 5 is $3.65^{o}C$, while that across perspex plate 6 is $4.04^{o}C$. The discrepancy between these two readings is 10%. Tables 4-4 to 4-8 show the temperature drops across the various specimens with different hole sizes.

Figure 4-1 shows the variation of total heat transferred with specimen thickness. Using the results of 5.6mm and 11mm thick perspex specimens with 30.5mm holes, the heat transferred is plotted against the temperature drop. As expected, for the same temperature drop, the thicker specimen transfers more heat than the thinner one. Also shown in the Figure are the curves of heat flux versus temperature drop for solid specimens. Again, as expected, the introduction of 30.5mm holes lowers the thermal conductances in both cases. Figure 4-3 shows the same results as described above, but using durotherm. It is significant that the plot of heat flux versus temperature difference across the specimen passes through the origin in all cases which have been plotted.

For the same material, the effect of hole size is shown in Figure 4-2. Using the results of 11mm thick perspex plate 5, the heat transferred is plotted against the temperature drop for the three holes used (30.5, 35.5 and 40.5mm). For the same heat flux, the temperature drop across the specimen increases significantly with hole diameter. For example, with a hole diameter of 30.5mm and the total heat transferred equal to 3.7 watts, the temperature drop is 5.5^{o}C. At the same heat flux but with a hole diameter of 40.5mm, the temperature drop across the specimen is 7.5^{o}C which is a 36% increase.

The importance of radiation transfer was assessed by putting aluminium foil in the holes (Chapter 3). Using perspex plates numbered 1 to 8, the results shown in Table 4-5 were obtained. Since the holes in the specimens were 30.5mm in diameter, the temperature drops (voltage settings) used were similar to those used in the results shown in Table 4-4. The temperature drops obtained for runs with aluminium foil in the holes were not significantly different from those obtained without aluminium foil in the holes. For example, from Tables 4-4 and 4-5 (runs 159 and 237):

(a) Plate 5 -

temperature drop without aluminium foil = $3.65^{\circ}C$

temperature drop with aluminium foil = $3.68^{\circ}C$

increase in temperature drop = $0.03^{\circ}C$

(b) Plate 6 -

temperature drop without aluminium foil = $4.04^{\circ}C$

temperature drop with aluminium foil = $4.12^{\circ}C$

increase in temperature drop = $0.08^{\circ}C$

These results appeared to show that radiation transfer was not significant at the temperatures at which the perspex runs were being performed. Approximate calculations of radiation transfer using Series 'A' results and the assumption that heat transfer was between infinitely parallel plates, the amount of radiation was found to be about 5% of the total heat transferred (147). Durotherm was used in later experimental runs since it was able to be heated to temperatures above $80^{\circ}C$. However, later results from the computer calculations appear to show that radiation is quite significant.

The Rayleigh and Grashof numbers for the experimental runs (used in the numerical simulations) are presented in Table 4-9. For all the perspex runs, the Rayleigh numbers are below the critical value of 1709 and similarly the Grashof numbers are below 2200. For the durotherm runs (runs 605 to 629), only runs 605 and 629 are below the critical limits. Runs 617 and 624 were carried out to determine the effect of convection in the transition region, while run 611 was on the transition-conduction boundary. As Figure 4-3 shows, there is no significant convection. Consequently, all the durotherm runs were used in the numerical simulations.

5.3 DISCUSSION OF THEORETICAL RESULTS

5.3.1 CREDIBILITY OF THE COMPUTED RESULTS

The validity of the computed results reported in this work can be judged from the following principal factors:

(a) fidelity of the computer program

(b) reliability of heat balances

(c) convergence of the solution

(d) comparison with experimental data

5.3.1.1 Fidelity of the Computer Program

This factor presents no small problem. Numerous simulation runs (not all described here) were devised to attest the fidelity of the computer program. These included solving the problem for various geometrical arrangements, relaxing the radiation temperatures, ignoring air conduction in the hole and solving the problem by using various radiation transfer approximations.

5.3.1.2 Accuracy of the Results

The basis of the computer program is attaining heat balances. The error percentage in all the heat balances was less than 0.03% (for every nodal point and in all the simulation runs).

5.3.1.3 Convergence

The solutions converged for:

(a) Different grid sizes - the different hole diameters (30.5, 34.925, 35.5 and 40.5mm) and the different specimen thicknesses meant that the distances between the nodal points varied

(b) Different boundary and initial conditions (temperatures)

(c) Different emissivities - the emissivities of aluminium used were 0.04, 0.11, 0.2 and 0.5

(d) Different problem data - thermal conductivities of air, perspex and durotherm

The temperatures converged to within $\pm$ 0.00001^{O}C.

However, when the temperatures of the hot and cold aluminium plates were increased to about 1000 and 800^{O}K respectively (using exactly the same linear problem dimensions as used in the low temperature simulations), convergence did not occur. This point requires further work.

5.3.1.4 Experimental Verification of Computer Solutions

The ultimate test of validity of the computer results rests with comparison with experimental results. From Tables 4-13 and 4-14, the computer results were always less than the experimental results. Using the computed results with an aluminium emissivity of 0.04, the discrepancy between the experimental and the theoretical results varies between 4 and 26%.

5.3.2 TEMPERATURE AND HEAT FLUX PROFILES

Figures 4-4 and 4-5 show the temperature profile of simulation run 692A. The hot boundary temperature is 66.76°C and the cold boundary temperature is 55.63°C. The temperature gradients in the Z-X plane are small. For example, in the conduction region C2, the temperature varies between 62.92°C (for nodal point 198) and 63.05°C (for nodal points 222, 236 and 237). The large temperature gradients occur in the Y-direction; the direction of the hot aluminium plate to the cold aluminium plate. Consider for example nodal point 188 (in the C2 region); its temperature is 63.02°C. The corresponding point in the C3 region is nodal point 314 with a temperature of 59.34°C.

Figures 4-6 and 4-7 show some of the heat flows of simulation run 692A. In the solid, most of the heat flows in the Y-direction. Consider point 216; the flow of heat in the Y-direction is 0.67×10^{-3} watts, whereas in the Z and X directions it is in the order of magnitude 10^{-5} watts. For some surface points, the radiation flow is significant. Consider point 158 for example; the solid conduction in the Y-direction is 0.11×10^{-2} watts. Radiation flow away from surface point 158 is 0.18×10^{-3} watts (this is about 16% of the conduction flow). Similarly, for surface point 132, the radiation flow is 0.91×10^{-4} watts, while the conduction flow in the Y-direction is 0.62×10^{-3} watts. Hence the approximate ratio of radiation flow to conduction flow at this node is 1:15. Air conduction is often of the same order of magnitude as radiation. Consider nodal point 129; the heat flow in the Y-direction is 0.36×10^{-3} watts (radiation away from the surface point 158 is $.18 \times 10^{-3}$ watts).

Table 5-1 shows the computed major heat flows entering and leaving the cavity and solid material in the direction perpendicular to the hot and cold plates (Y-direction) for the runs simulating 12mm thick durotherm and perspex with 35.5mm holes. The heat flows apply to one eighth of the block of material (Figure B1). For most of the results shown (Table 5-1), the proportions of heat travelling through the solid as conduction, through the cavity as air conduction and through the cavity as radiation can be seen to be roughly 1, 0.11 and 0.05.

5.3.3 EFFECT OF MATERIAL THICKNESS

Run 341A used 5.6mm thick perspex with 30.5mm holes. The temperature drop across the specimen was 3.4^{o}C. The computed total heat transfer was 3.185 watts.

Run 159A used 11mm thick perspex with 30.5mm holes. The temperature drop across the specimen was 3.65^{o}C. The computed total heat transfer was 1.981 watts.

From runs 341A and 159A, it is observed that for about the same temperature drop, the thinner specimen transfers proportionately more heat than the thicker one. This is in agreement with the experimental results shown in Figure 4-1.

5.3.4 EFFECT OF HOLE SIZE

For the same specimen and at the same temperature drops, the total heat transferred decreases with increases in hole diameter (size). The results of 11mm thick perspex plates with 30.5, 35.5 and 40.5mm holes show this trend (runs 159, 549 and 679 respectively). From Table 4-13, the total heat transferred for runs 159A, 549A and 679A is 1.981, 1.867 and 1.69 watts respectively.

However, the radiation contribution to the total heat transferred increases with increase in the hole size (Figure 4-9). For the same temperature drop, the perspex plates with 40.5mm holes transmit more heat by radiation than those with 35.5mm and 30.5mm holes.

5.3.5 THE EFFECT OF EMISSIVITY

For a fixed hole size, the effects of (aluminium) emissivity are:

(a) The heat transferred by solid conduction is practically constant for all values of emissivity (Figure 4-12 and Table 4-10). For example, in run 576, for emissivity values of 0.04, 0.11, 0.2 and 0.5, the solid conduction heat transfer is 5.222, 5.218, 5.213 and 5.196 watts respectively.

(b) Similarly, the heat transferred by gaseous conduction is virtually constant. In run 576, for example, for the same emissivity values mentioned above, the heat transferred by gaseous conduction is 0.607, 0.607, 0.606 and 0.606 watts respectively.

(c) Radiation transfer increases substantially with emissivity as expected. In run 576, for example, the heat transferred by radiation is 0.242, 0.31, 0.402 and 0.761 watts respectively for the four emissivity values 0.04, 0.11, 0.20 and 0.5. Figure 4-8 and Table 4-12 show this trend.

(d) From (c), the total heat transferred increases with emissivity. Figure 4-12 shows this trend. In run 576, for example, the total heat transferred is 6.071, 6.134, 6.221 and 6.563 watts respectively for the four aluminium emissivities.

As a result, the emissivity of the aluminium plates used in the guarded hot plate needs to be known accurately.

5.3.6 THE EFFECT OF RADIATION AND GAS CONDUCTION

Solid conduction is the dominant mode of heat transfer. In run 159A for example, the total heat transferred is 1.981 watts; solid conduction is 1.761 watts (which is 89% of the total). With increases in hole diameter and operating temperature, the solid conduction percentage drops. In run 698D, the total heat transferred is 6.747 watts, with a solid conduction contribution of 4.638 watts (68%). As a result, the contributions of radiation transfer and gaseous conduction vary between about 10 and 30% of the total heat transferred.

In run 159A for example, the radiation contribution is 0.046 watts (2% of the total heat transferred), whereas the air conduction contribution is 0.175 watts (9%).

In run 698D, the radiation contribution is 0.993 watts (15%) and the air contribution is 1.116 watts (17%).

Figures 4-10 and 4-11 show the contributions of each of the mechanisms of heat transfer, using durotherm and perspex results respectively. The trends mentioned above are verified.

5.4 DISCUSSION OF APPARATUS PERFORMANCE AND THEORETICAL ANALYSIS

In all the runs, the total heat transferred by experiment is greater than that transferred by theoretical analysis (Table 4-13). For example, in run 159, the total heat transferred by experiment is 2.294 watts. From the numerical simulations, the total heat transferred is 1.981, 1.991, 2.005 and 2.059 watts (for the four aluminium emissivities). Table 4-14 shows that the discrepancy between the experimental and the theoretical results varies between 2 and 26%. As expected (section 5.3), the results with the aluminium emissivity of 0.5 show the lowest discrepancy percentages. However, from the literature (1, 148) the emissivity of oxidised aluminium is expected to be between 0.04 and 0.2. The measured emissivity quoted earlier agrees with these figures.

In Figure 4-13, the total heat transferred is plotted against the temperature drop for both the experimental and theoretical results. The trends mentioned above are shown.

5.4.1 PERSPEX RESULTS

Considering the results with aluminium emissivities of 0.04, 0.11 and 0.2, about half of the results have discrepancies greater than 12%.

Swann (47,48) measured the total heat transferred across honeycomb-core sandwiches experimentally using a guarded hot plate. He performed a theoretical analysis as well. The discrepancy between his experimental and theoretical results was about 30%. Consequently, the discrepancies found in this work were not totally unexpected or unreasonably high.

5.4.2 DUROTHERM RESULTS

For all the durotherm results, the discrepancies between the experimental and the theoretical results are less than 12%. The exception is run 624A where the discrepancy is 13.7%. Possible reasons why the durotherm runs gave better results than the perspex runs were:

(a) Durotherm was heated to higher temperatures (from $77^{o}C$ to $162^{o}C$) while perspex was heated only up to $76^{o}C$. As a result, the durotherm experimental temperature drops were higher in the range 16 to $50^{o}C$, whereas the perspex results were in the range 0.8 to $15^{o}C$. If this reasoning is correct, it implies a large undiscovered error in the experimental measurements which needs further investigation.

(b) Durotherm is opaque while perspex is partially transparent. The thermal conductivity of durotherm determined was the true thermal conductivity. That determined for perspex was the apparent one due to the contribution of radiation. Although approximate calculations showed that radiation was not significant in the perspex, the suspicion remains that some radiant transmission may have affected the results. Since the aim of this work was to establish an easy method of determining heat transfer in the cavity problem, it was unfortunate that the only material available locally was the partially transparent perspex. If significant transmission can be shown to be taking place, the net radiation method would have to be modified so as to take account of the partially transparent perspex walls (53,149,150).

5.5 CHARACTERISTICS OF THEORETICAL RESULTS

The computed behaviour of the various heat transfer modes through the durotherm follows closely what would be expected. All transfers increase smoothly with temperature and the radiation transfer tends to increase with temperature at a rate somewhat greater than the conduction transfers (Figure 4-10).

However, the computed behaviour of the air conduction in the perspex cavities is disquietening, see Figure 4-11. The sudden rise in the air conduction with the first increase in temperature drop across the specimen is followed by a much smaller rise in heat flow as the temperature drop is increased. This effect has been emphasised by the line drawn through the points along what would have been the expected trend.

The reason for this behaviour has not been found. Although the air conduction is quite a small part of the total heat transfer, it might be affected substantially by small errors in the various heat balances. In fact, the heat balance at all nodes was correct to 0.03% of the net heat flow through the node. With this degree of accuracy, the deviation noted in air conduction would not be expected to arise from this cause.

The effect can be seen in more detail in Table 5-1 in the columns describing air conduction.

It also seems unlikely that the deviations, if they are deviations, occur because of incipient instability in the convergence. As mentioned earlier, convergence was not obtained at temperatures around 900^{o}K, but the durotherm calculations were carried out at temperatures about 50^{o}C higher than those used for perspex, and the durotherm results appear perfectly stable. Great care was taken to ensure that no 'rogue' (wrong) data had been used in the computer program during these calculations (none could be found). Further work needs to be carried out to find the cause of the behaviour of air conduction as shown in Figure 4-11.

TABLE 5-1

Major Computed Heat Flows (In Watts)

(PMMA With 35.5mm Holes Runs 549 to 576 and Durotherm Runs 605 to 629)

Run Number	Solid Conduction			Air Conduction			Radiation	
	Solid Conduction Regions			Air Conduction Regions			Radiation Regions	
	C2	C3	C4	C2	C3	C4	1 and 2	5 and 6
	Entering	Mid-Plane	Leaving	Entering	Mid-Plane	Leaving	Entering	Leaving
549B	0.0125	0.0123	0.0125	0.0013	0.0013	0.0013	0.0005	0.0005
556B	0.0196	0.0191	0.0192	0.0031	0.0019	0.0012	0.0009	0.0008
568B	0.0297	0.0291	0.0297	0.0040	0.0020	0.0036	0.0014	0.0014
576B	0.0395	0.0388	0.0393	0.0047	0.0047	0.0037	0.0020	0.0020
605B	0.0452	0.0443	0.0452	0.0047	0.0045	0.0047	0.0024	0.0024
611B	0.0663	0.0649	0.0664	0.0072	0.0069	0.0072	0.0041	0.0039
617B	0.0849	0.0830	0.0852	0.0095	0.0090	0.0095	0.0059	0.0056
624B	0.1445	0.1405	0.1454	0.0175	0.0165	0.0176	0.0137	0.0127
629B	0.0552	0.0541	0.0553	0.0059	0.0056	0.0059	0.0032	0.0031

5.6 DISCUSSION CLOSURE

No other work was found in the literature which solved the cavity problem. However, the work of Swann (47,48) and Stroud (60) on honeycomb-core sandwich panels was used to check the heat transfer results obtained (147). The radiation transfer results obtained in this work were of the same order of magnitude as those obtained using the 'Swann-Stroud' equations, despite the fact that in honeycomb-core structures, solid conduction is negligible.

CHAPTER 6

CONCLUSION

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CONCLUSION

The aim of this work was to develop simple experimental and theoretical methods of solving the equations which describe the heat transfer processes in a cavity, and thereby to investigate the assumptions and mechanisms significant to the cavity problem.

The equations describing the heat transfer processes have been solved computationally. Experimental verification of the results has also been carried out. Using durotherm specimens, the theoretical results were in agreement with the experimental results within the limits of the experimental error. For perspex specimens however, the discrepancy between the experimental and the theoretical results varied between 2 and 26%.

For various geometries, orientations and materials, the developed computer program gives the following:

(a) solid conduction heat flows

(b) gaseous conduction heat flows in the holes

(c) radiation flows between the surfaces in the holes

(d) temperature profiles

Without too many modifications, the effects of convection transfer can be incorporated in the program. The program uses simple heat transfer theory and is not too mathematical, consequently, the computing time is small (typically, 30 seconds Central Processing Unit time - Burroughs 6700).

The experiments have shown the lack of:

(a) reference materials with which the experimental results obtained in this work could have been compared with

(b) suitable materials - although durotherm gave satisfactory results, it is not a good material to work with because it is carcinogenic

(c) suitable experimental methods of measuring radiation transfer and solid conduction separately

The experimental results have shown that (in the cavity problem) at atmospheric pressure, it is not possible to get large temperature drops across the holes without natural convection starting to occur. In the durotherm runs with temperature drops greater than $16^{\circ}C$, the Rayleigh numbers were greater than Ra_c. In order that the cavity problem be studied experimentally at high temperatures ($600^{\circ}K$) where radiation is the dominant mode of heat transfer, the apparatus needs to be evacuated.

The problems associated with different temperature drops across the specimens can to a large extent be overcome by having reference materials and suitable specimens to work with. Using suitable specimens, the enclosure containing the guarded hot plate could be filled with insulation of one type, for example, fibreglass. In this work, a polystyrene-air insulation system was used so that reasonable temperature drops across the perspex specimens could be obtained. With insulation of one type in the box, the uncertainty of the external resistance could be overcome.

CHAPTER 7

RECOMMENDATIONS FOR FUTURE WORK

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RECOMMENDATIONS FOR FUTURE WORK

7.1 EXPERIMENTAL WORK

The number and nature of the experiments undertaken in this work were limited by:

(a) the operating temperature

(b) the materials available - initially perspex and later durotherm

(c) temperature measuring equipment - the lack of a digital potentiometer meant that few millivolt readings were taken

(d) the lack of methods of measuring the contributions of gaseous conduction, solid conduction and radiation transfer separately

In future experimental studies using the apparatus built in this work, the author considers that the above four points need to be studied closely. By finding a suitable material to work with, for example, insulation material of the type MIN-K (6), the apparatus could be operated at higher temperatures and consequently the radiation contribution effects studied at temperatures at which they are significant. At high temperatures however, natural convection becomes significant. If it is required to suppress it, evacuating the apparatus would achieve this. However, if it is not required to suppress natural convection, its importance could be assessed by using a Mach-Zehnder Interferometer.

There is a need for research into experimental methods of measuring solid conduction in the presence of radiation. No work was found in the literature which experimentally measured solid conduction (or radiation) separately in the presence of radiation (or solid conduction). By introducing pressure as a variable in the apparatus built, the effect of gaseous conduction can be assessed.

In order that the total heat transferred be known accurately, metered cooling coils need to be put in the cold aluminium plates.

7.2 THEORETICAL WORK

The potential importance of finite element and finite difference methods for the solution of enclosed heat transfer problems warrants more theoretical investigations. In three dimensions especially, very little work was found. Considerable work remains regarding irregular boundary conditions.

Theoretical studies of natural and forced convection in conjunction with the radiation-conduction studies of this work need to be done, especially natural convection which has a myriad of correlations.

The techniques used to ensure convergence between the radiation and conduction calculations also need further study. A more sophisticated attempt to take account of radiation changes during the solution of the heat balance equations is needed especially at high temperatures ($1000^{\circ}K$).

In conjunction with the experiments, the emissivity of aluminium needs to be known accurately.

7.3 CONCLUDING REMARKS

Future work on the cavity problem should also be concerned with transient state problems.

The cavity problem needs to be studied both experimentally and theoretically for typical large scale configurations, that is, a scale up of the linear dimensions and conditions used in this work.

NOMENCLATURE

This consists of two sections:

(a) Part I - the symbols used in the text (the thesis)

(b) Part II - the main variables used in the computer program (cavity problem computer program)

PART I

A cross sectional area perpendicular to the direction of heat flow (M^2)

B angle between 'conduction-rods' Figure B3 (degrees)

C_p specific heat at constant pressure (kJ/kg^oK)

CXY, CYX, and CZX conductances ($W/^oC$) see part II of this section

D diameter (M)

dQ_r/dT change in radiant flux as the temperature being relaxed is changed in the heat balance equations ($W/^oK$)

dT temperature drop (^oC)

E emissive power of a radiating body (W/M^2)

e emf in millivolts

F configuration (shape) factor - see part II

g acceleration due to gravity (M/s^2)

Gr Grashof number based on a characteristic dimension for example L in Figure 1-1

$$= g\beta(T_h - T_c)L^3\rho^2/\mu^2$$

K thermal conductance ($W/^oC$)

k thermal conductivity (W/M^oC)

L,l length (M)

N number of surfaces in enclosure

Nu Nusselt number for natural convective heat transfer across an air layer

$= q \times L/(k \times dT)$

PMMA, pmma Polymethyl methacrylate - perspex

Pr Prandtl number $= C_p\mu/k$

Q heat transfer rate (W)

q energy flux, energy per unit area and time (W/M^2)

Q_{r3} radiation heat flow in equation (1-12)

QXY, QYX, and QZX solid conduction heat flows (W) - see part II

R radius (M)

Ra Rayleigh number = Gr x Pr

based on L it is

$= g\beta\rho^2(T_h - T_c)L^3C_p/(\mu k)$

r_i inside radius (M)

r_o outside radius (M)

Stark number the conduction-radiation parameter based on the j th temperature defined by

$N_j = ka/4\sigma T_j^{\,3}$

where 'a' is the absorption coefficient

T temperature (^oC, ^oK)

V voltage in electrical analogy (W/M^2)

α absorptivity

β coefficient of thermal expansion

δ Kronecker delta

ε emissivity

λ wavelength in microns

ℓ reflectivity

ρ density (kg/M^3)

σ Stefan-Boltzmann constant

μ fluid viscosity (Ns/M^2)

SUBSCRIPTS

a	apparent
b	blackbody property
c	critical, that is, at the onset of convection
gc	gaseous conduction
i	incoming
i	initial
j,k	property of surface j or k
o	outgoing
r	radiative
sc	solid conduction
λ	spectrally (wavelength) dependent

UNITS

^oC	degrees Celsius
^oK	degrees Kelvin
M	metres
mV	millivolts
W	watts

PART II

The main program variables in the approximate order found in the program are:

NPITER	number of program iterations
NX	number of points in the X-direction (in the grid Figures B2 to B5, NX = 14)
NY	number of points in the Y-direction (number of constant temperature regions in Y direction - Figure B1, NY = 4)

NZ number of points in the Z-direction (Figures B2 to B5, NZ = 9)

E(I) emissivity of surface 'I'

TKAIR thermal conductivity of air. (W/M^{O}C)

R radius of the cavity hole (M)

AA surface area of surface points (M^2)

AR(I) area of radiation region 'I' (M^2)

TR(I) temperature of radiation region'I' (^{O}K)

T(J) temperature of nodal point 'J' (^{O}C)

QO(I) radiosity of region 'I' (W/M^2)

QRADTO(I) net radiative loss from surface 'I' resulting from radiation in the enclosure (M^2)

QRAD(I,J) radiation heat flow to surface point as defined in Appendix B (W)

DQDT(I,J) the change in radiant flux as the temperature being relaxed is changed (see equation 1-17)

F(I,J) radiation shape factor, that is, the fraction of diffusely distributed radiation leaving a surface 'I' that reaches surface 'J'

CXY(J) conductance in X-direction between nodal points 'J' and 'J + 1' (W/^{O}C) - for example, in Figure B3, CXY(201) is the conductance between nodal points 201 and 202

CYX(J) conductance in Y-direction between nodal points 'J' and 'J - (NX * NZ)' (W/^{O}C) - for example, in Figures B3 and B4, CYX(272) is the conductance between nodal points 272 and 146

CZX(J) conductance in Z-direction between nodal points 'J' and 'J + NX' (W/^{O}C) - for example, in Figure B3, CZX(187) is the conductance between nodal points 187 and 201

TKP thermal conductivity of specimen ($W/M^{o}C$)

DELTAY thickness of specimen divided by 3 - see Figures B1 and B9 (M)

HC, AC, and DC coefficients used in evaluating conductances - see subroutine conduc

R1, R2, R3, and R4 radii used in air conductances evaluations (see Figure B8 and subroutine conduc)

CRAD(I) constant value in relaxation equation - it is equal to zero when considering interior points - for surface points it is equal to QRAD(I,J) (W)

RES(I) temperature residual of equation B-23 (^{o}C)

QXY(J) heat flow in the X-direction from nodal point 'J' towards nodal point 'J + 1' (W) - for example, in Figure B4, QXY(300) is the heat flow from nodal point 300 towards nodal point 301

QYX(J) heat flow in the Y-direction from nodal point 'J' towards nodal point 'J - (NX * NZ) (W) - for example, in Figure B4, QYX(325) is the heat flow from nodal point 325 towards nodal point 199

QZX(J) heat flow in the Z-direction from nodal point 'J' towards nodal point '(J + NX)' (W) - for example, in Figure B4, QZX(333) is the heat flow from nodal point 333 towards nodal point 347

HEATIN net heat flow into a nodal point (W)

HEATOUT(HITOUT) net heat flow from a nodal point (W)

TOTFLO the difference between the HEATIN and the HITOUT (W)

PECERR the 'out-of-balance' error percentage, that is, TOTFLO divided by the mean of HEATIN and HITOUT (%)

SUMQXY net solid heat flow in X-direction (W)

SUMQYX net solid heat flow in Y-direction (W)

SUMQZX net solid heat flow in Z-direction (W)

QXYAIR net air conduction heat flow in X-direction (W)

QYXAIR net air conduction heat flow in Y-direction (W)

QZXAIR net air conduction heat flow in Z-direction (W)

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164. Aluminium Co. of Canada Ltd, 'Handbook of Aluminium', Montreal, 1957

165. Leuenberger H., 'Compilation of Radiation Shape Factors for Cylindrical Assemblies', ASME paper no 56-A-144, July 1956

166. Pivovonsky M., Nagel M.R., 'Tables of Blackbody Radiation Functions', Macmillan Co., N.Y., (1961)

167. U.S. National Bureau of Standards, Circular 564, 'Tables of Thermal Properties of Gases'

168. Watson J.T.R., 'Viscosity of Gases in Metric Units', Dept of Trade and Industry, National Engng Laboratory HMSO, 1972

APPENDIX A

MISCELLANEOUS DATA

A1 THICKNESSES OF THE SPECIMENS

The thicknesses of the various materials (specimens) used in the guarded hot plate are:

TABLE A1

Thicknesses of the Specimens

Specimen Plate Number	Material	Nominal Thickness (inches)	Average Thickness (millimetres)
1	Perspex	1/4	5.69
2	Perspex	1/4	5.54
3	Perspex	1/4	5.66
4	Perspex	1/4	5.64
5	Perspex	1/2	11.15
6	Perspex	1/2	11.20
7	Perspex	1/2	11.21
8	Perspex	1/2	11.17
9	Perspex	3/4	19.03
10	Perspex	3/4	19.08
11	Perspex	3/4	19.08
12	Perspex	3/4	19.05
13	Particle Board	3/4	19.70
14	Particle Board	3/4	19.71
15	Syndanyo Board	3/8	9.70
16	Syndanyo Board	3/8	9.74
17	Polystyrene	1/2	12.70
18	Polystyrene	1/2	12.70
19	Durotherm	1/2	12.07
20	Durotherm	1/2	12.12
21	Tufnol Spacers	1/2	11.25
22	Tufnol Spacers	1/2	11.25

A2 PROPERTIES OF PERSPEX

The mechanical, thermal, optical, and electrical properties of perspex are given in the I.C.I. publication – 'Properties and Perspex' (145). Other publications with properties of perspex are:

(a) Ogorkiewicz (151)

(b) Imperial Chemical Industries Ltd (152)

(c) Roff (153)

(d) Wyatt (154)

(e) Thermophysical Properties of Matter (146)

(f) Jenkins (155)

(g) Clark (156)

The thermal properties from the I.C.I. publication (145) are:

TABLE A2

Thermal Properties of Perspex

Property	Units	Mean Value
1/10 Vicat softening point	^{o}C	100
Temperature of deflection under load (in accordance with BS 2782, Part 1, method 102G at a fibre-stress of 18.5 kgf/cm^2)	^{o}C	100
Demoulding temperature	^{o}C	87
Maximum service temperature	^{o}C	80
Thermal conductivity at $20^{o}C$	$W/M^{o}C$	0.188
Coefficient of thermal expansion at $20^{o}C$:		
volume	$/^{o}C$	2.2×10^{-4}
linear	$/^{o}C$	7.3×10^{-5}

A2.1 RADIATIVE PROPERTIES OF PERSPEX

Reflectance, absorptance and transmittance data is available in the thermophysical properties books (146). The emissivity of perspex could not be found in the literature.

PREDICTION OF THE EMISSIVITY OF PERSPEX

Using classical electromagnetic theory, the emissivity of perspex was calculated as follows:

(i) Assumptions:

- perspex is a dielectric (Dielectrics are materials which are insulators, that is, have direct current resistivities greater than 10^8 ohm-cm. Clark (156) gives the resistance of PMMA as 10^{15} ohm-cm.)

- perspex is isotropic -That is, electrical and internal optical properties are independent of direction.

- the magnetic permeability of perspex is equal to that of a vacuum

- no accumulation of static electrical charge

- no externally produced electrical conduction currents present

(ii) Mathematical Formulation:

The normal emissivity is computed from the formula

$$\varepsilon_n = 1 - \left(\frac{n-1}{n+1}\right)^2 \qquad \text{(A-1)}$$

where ε_n = the normal emissivity

n = the refractive index of perspex

The refractive index of perspex does not vary appreciably with wavelength (151). $n = 1.59$ was chosen.

Therefore,

$$\varepsilon_n = 1 - \frac{(1.59 - 1)}{(1.59 + 1)}$$

$$= \underline{0.95}$$

The relationship of the normal emissivity to the hemi-spherical emissivity is well known (Graphical representation in Siegal's book (14)).

At a normal emissivity of 0.95, the ratio of the hemi-spherical emissivity (ε) to the normal emissivity is equal to 0.935, that is,

$$\varepsilon/\varepsilon_n = 0.935$$

hence, $\varepsilon = 0.935 \times 0.95$

$$= \underline{0.9}$$

THE MEASURED EMISSIVITY OF PERSPEX

The emittance of perspex was measured at the Commonwealth Scientific and Industrial Research Organisation in Australia using the Gier-Dunkle Scanning Infra-Red Reflectometer.

The emittance of machined perspex was found to be 0.905. That of clear (unmachined) perspex was found to be 0.916. As the specimens used in the experiments were machined, the former figure was applicable.

A3 MISCELLANEOUS DATA

A3.1 ARALDITE

Araldite is a trade name of CIBA-GEIGY for an epoxy resin based adhesive. The epoxy resin system used in this work has the designations of Araldite AW106 and Hardener

HV953U. The general properties of araldite are outlined in the CIBA-GEIGY pamphlet (157).

TABLE A3

Properties of Araldite

	Araldite AW106	Hardener HV953U
Physical form	viscous epoxy resin	treacle-like, slightly alkaline liquid
Colour	cream	yellow
Viscosity at 25°C cP	30,000 - 50,000	25,000 - 40,000
Specific gravity at 25°C gm/c.c.	1.15 - 1.25	0.9 - 1.0
Flash Point °C (Pensky-Martens)	greater than 200	50 - 55

The thermal conductivity at a mean temperature of 28°C is given as 0.282 W/M°C (157).

A3.2 ALUMINIUM

In the design of the aluminium plates, the following references were used - 158, 159, 160, 161 and 162. Structural and other physical properties of aluminium are outlined in references 163 and 164.

For 99.95% pure commercial aluminium, the properties outlined in reference 164 are:

TABLE A4

Properties of Aluminium

Property	Units
Density at 20^{o}C	0.0975 psi
Melting Point	1220^{o}F (660^{o}C)
Young's Modulus	10^{7} psi
Modulus of Rigidity (shear)	3.79×10^{6} psi
Poisson's Ratio	0.33

The thermal conductivity of aluminium is well documented in the literature (1,146).

Numerous values of the emissivity of aluminium (different surface conditions) are available in the literature. The Thermophysical Properties book (146) presents forty four curves of the emissivity versus temperature. Gubareef (148) presents a thorough review of the emissivity values of aluminium and other radiative properties of various materials.

Since the aluminium plates were oxidised, from the above two references, values of emissivity were chosen. The chosen values were 0.04, 0.11, 0.2 and 0.5.

APPENDIX B

CAVITY PROBLEM THEORETICAL DERIVATIONS

APPENDIX B

CAVITY PROBLEM THEORETICAL DERIVATIONS

B1 PHYSICAL FORMULATIONS

As previously mentioned (Chapter 2 - Figure 2-12), the specimens used in the experiments had holes drilled in them in a regular pattern (square pitch). From the linear dimensions of each specimen, the block of material used in the numerical analysis is 47.66mm x 47.66mm x thickness of the specimen. The hole of chosen diameter is in the centre of this block of material (specimen). The leading dimensions of the cavity problem are shown in Figure B1. The diameters used for the perspex simulation runs were 30.5mm, 35.5mm and 40.5mm. For the durotherm simulation runs, only one diameter was used, 34.925mm (1 3/8").

From Figure B1, it is apparent that the cavity problem is symmetrical. Consequently, only 1/8th of the block of material was required to be analysed. For example, for solid conduction, the regions C1, C2, C3 and C4 in Figure B1.

B2 CHOICE OF ZONES

Three zoning systems were used.

B2.1 SOLID CONDUCTION ZONES

These are regions C1, C2, C3 and C4 in Figure B1. Each of these conduction regions had 58 nodal points. Figures B2 to B5.

B2.2 RADIATION REGIONS

Figure B6 shows the radiation regions. There are six radiation regions. Regions 1 and 6 are the two end discs

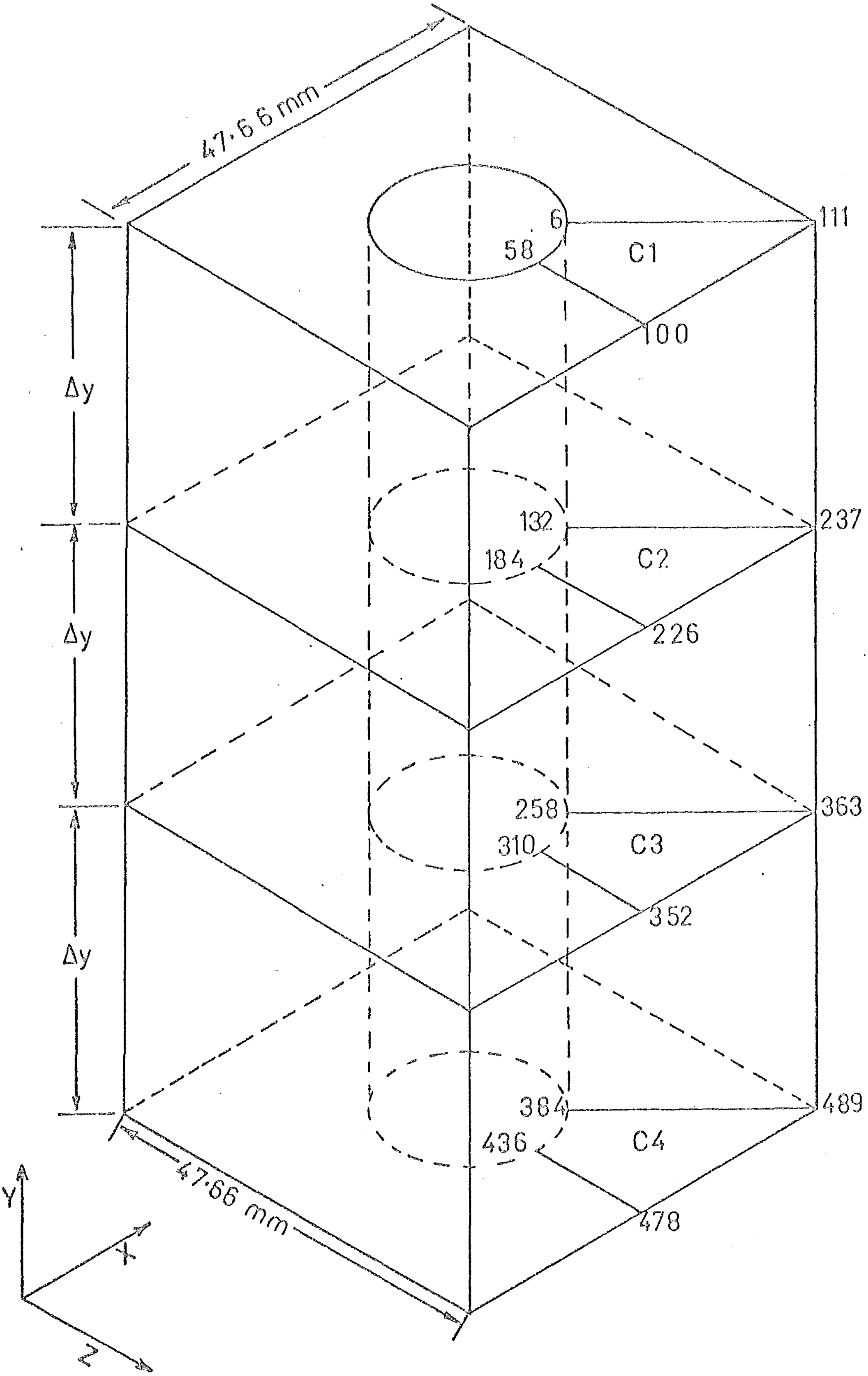


FIGURE B1 THE CAVITY PROBLEM PHYSICAL FORMULATION

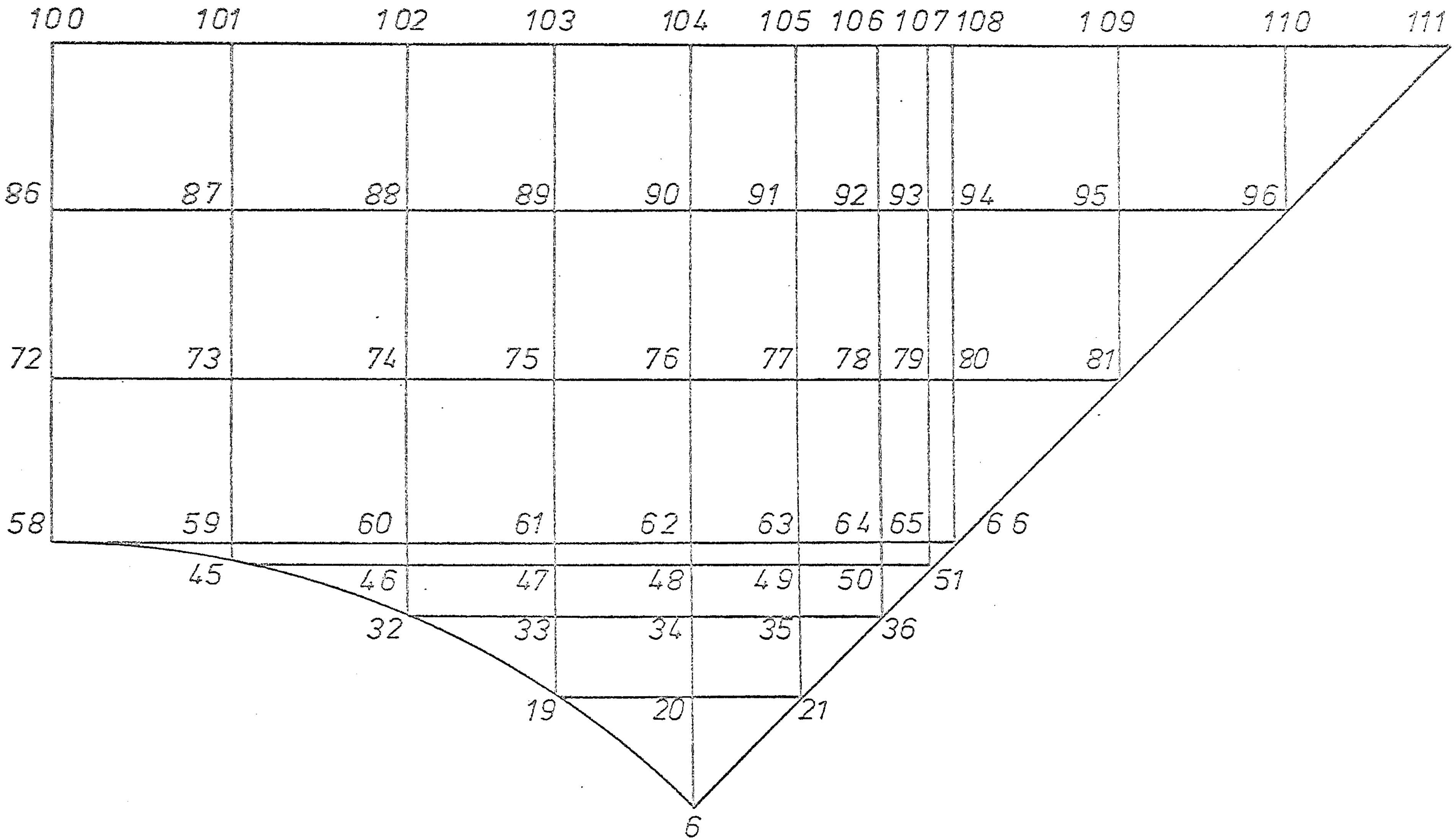


FIGURE B2 SOLID CONDUCTION ZONE C1-PLAN VIEW

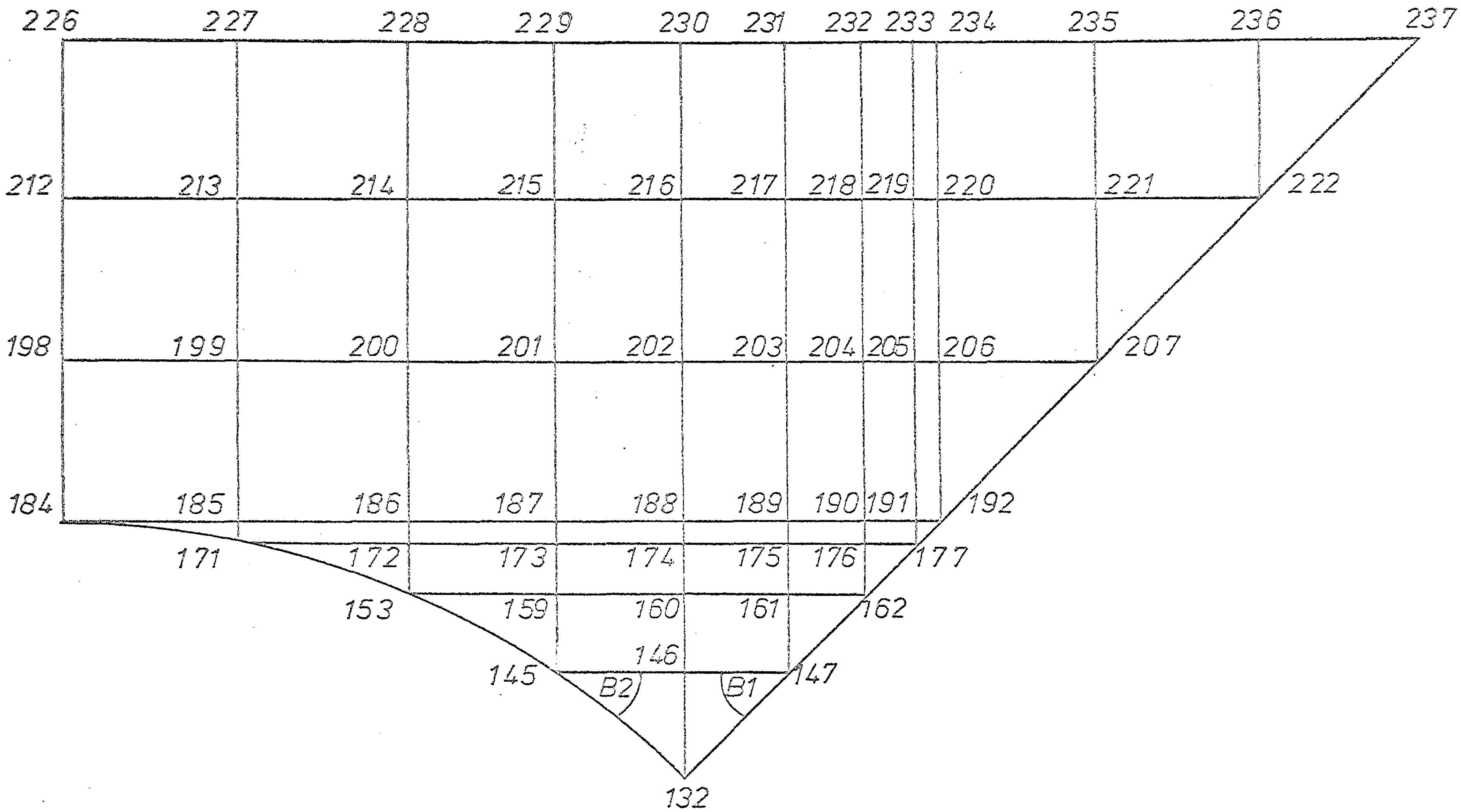


FIGURE B3 SOLID CONDUCTION ZONE C2-PLAN VIEW

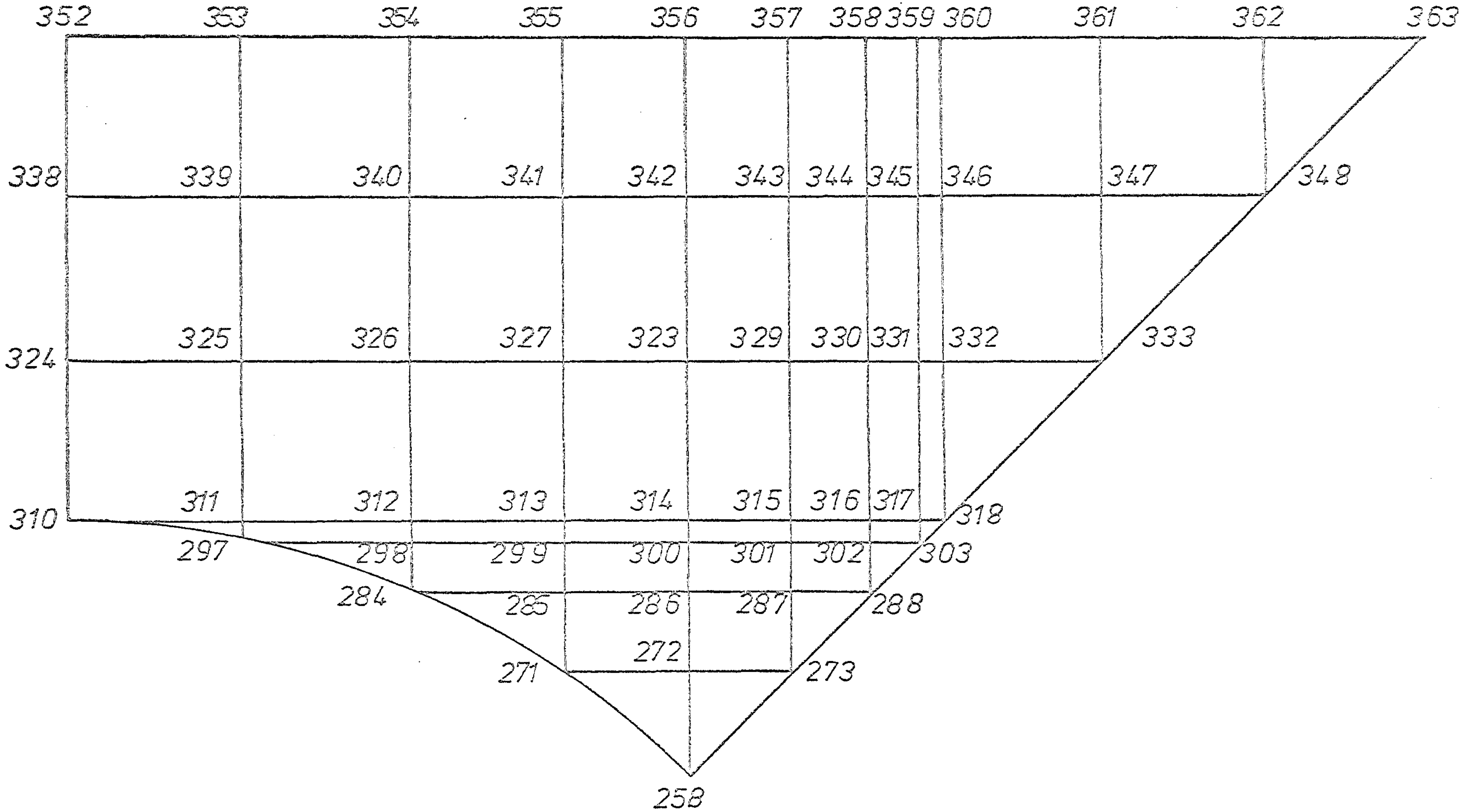


FIGURE B4 SOLID CONDUCTION ZONE C3-PLAN VIEW

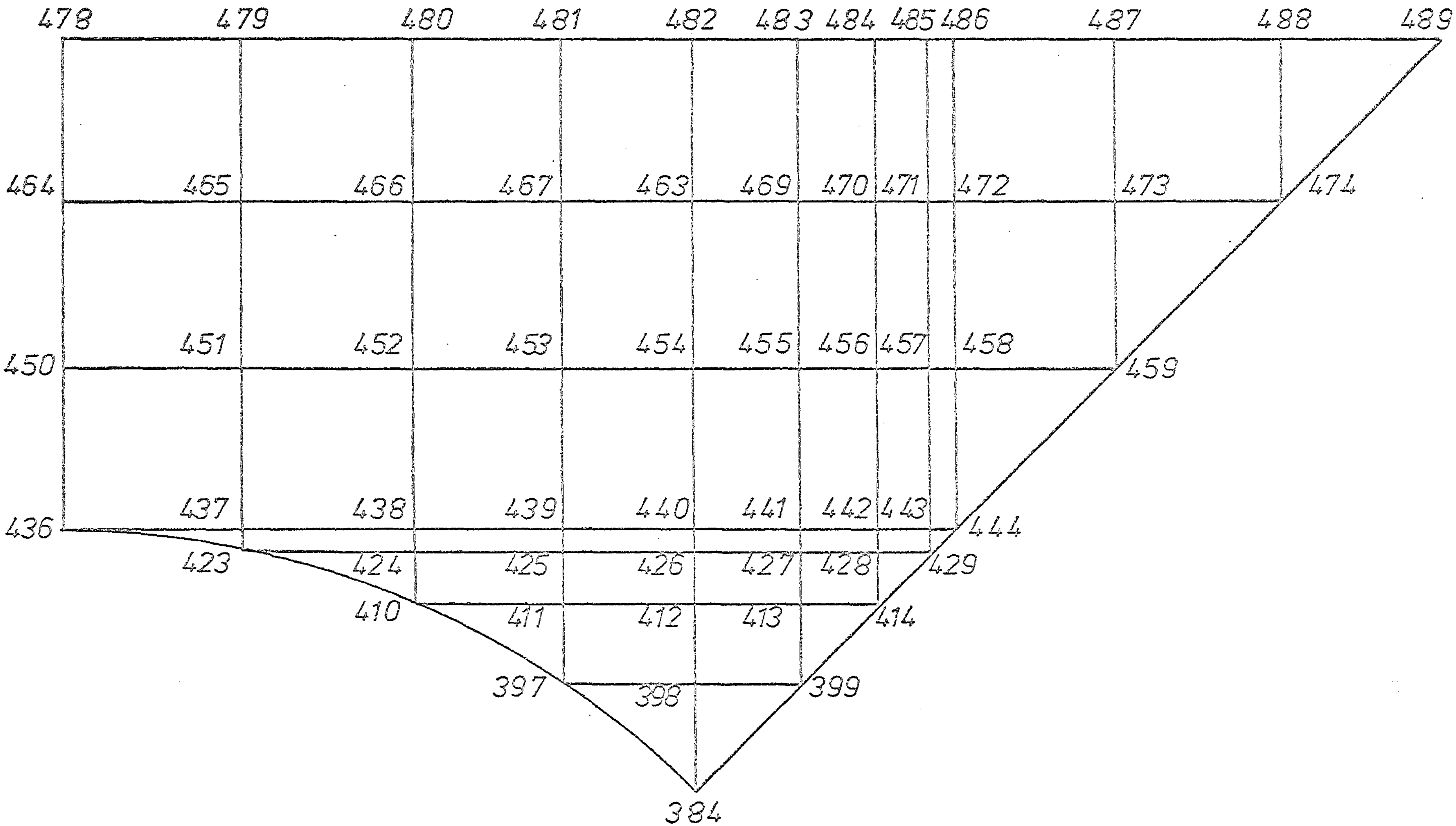


FIGURE B5 SOLID CONDUCTION ZONE C4- PLAN VIEW

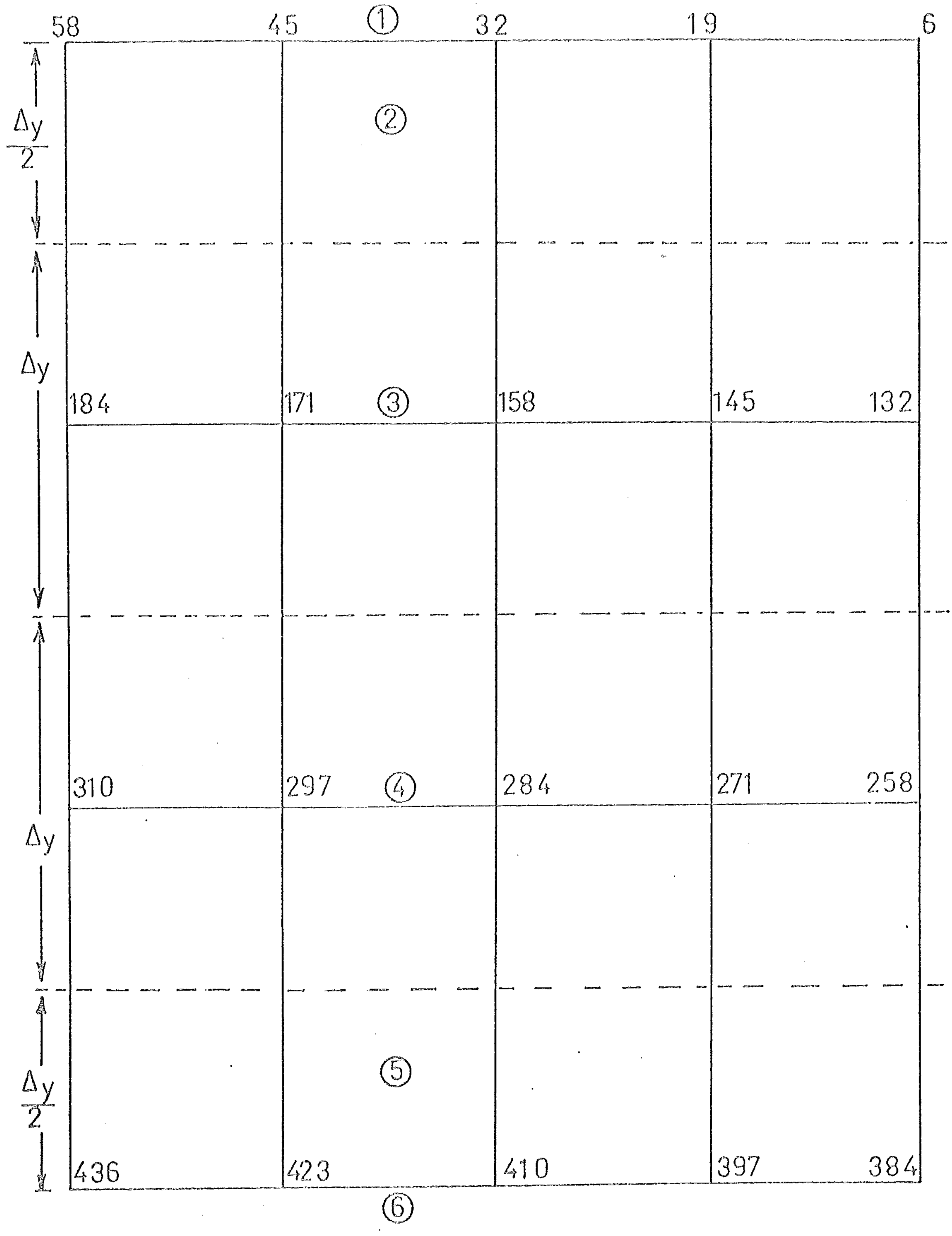


FIGURE B6 RADIATION REGIONS AND SURFACE POINTS

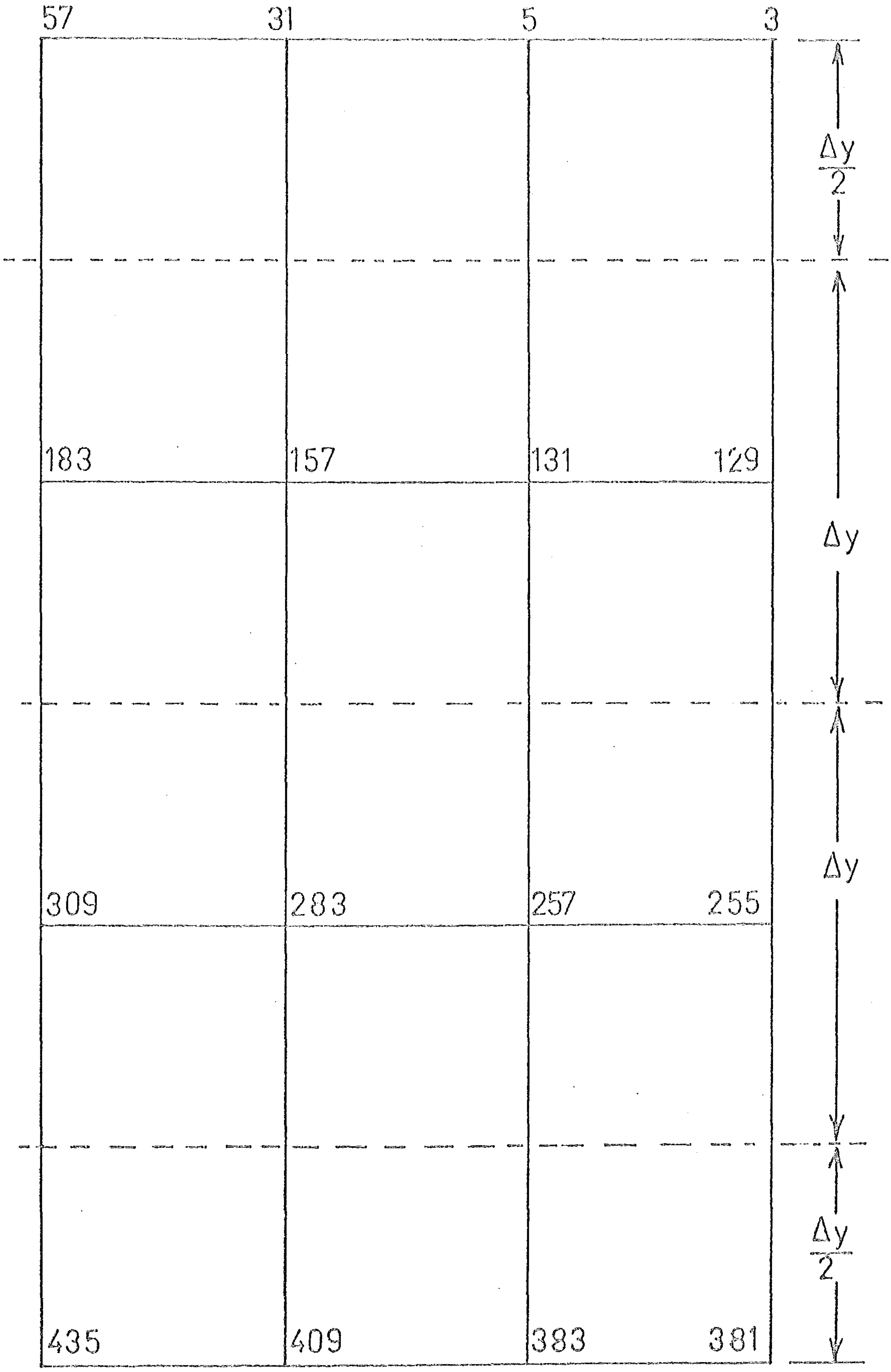


FIGURE B7 AIR CONDUCTION REGIONS

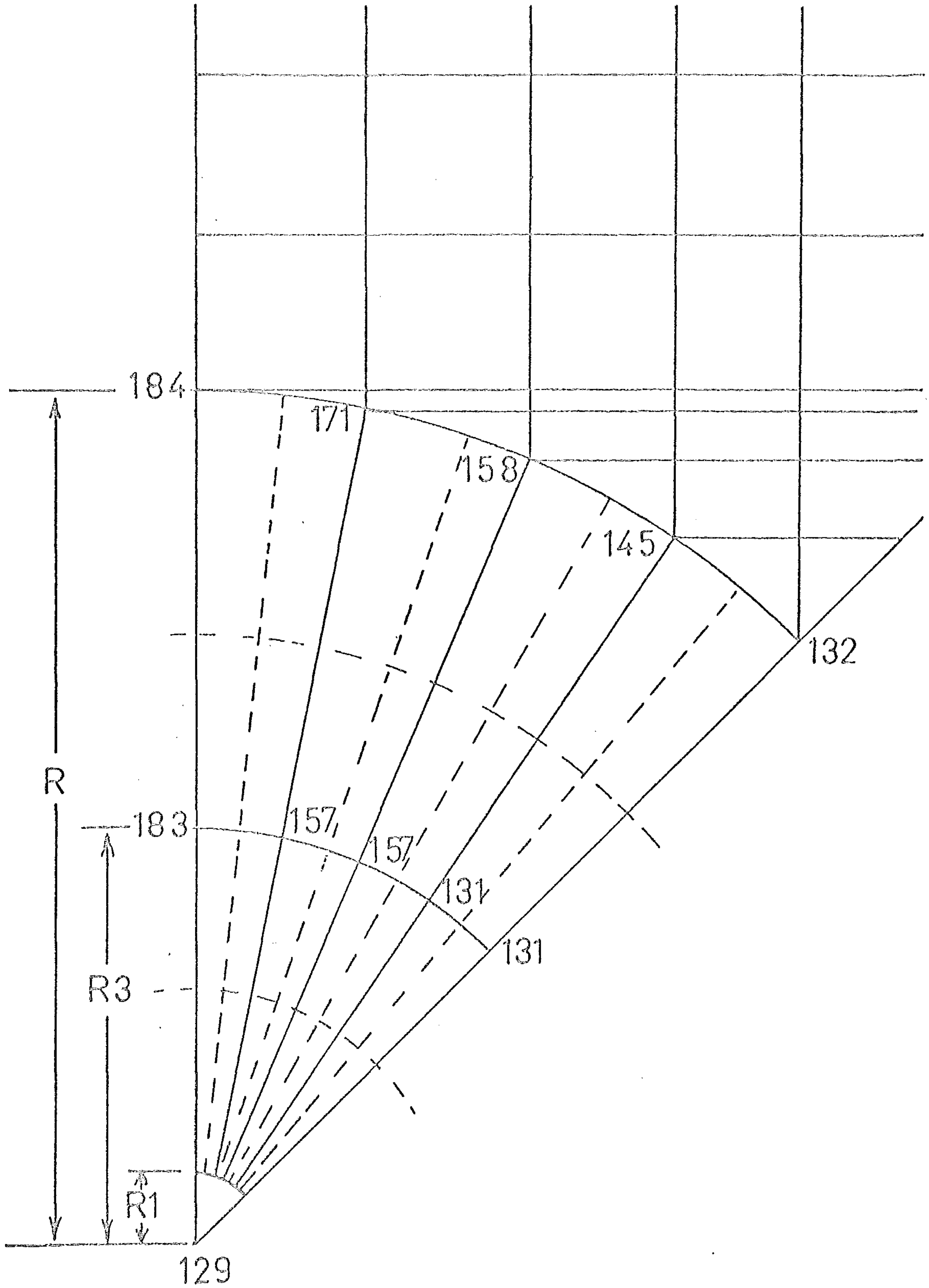


FIGURE B8 PLAN VIEW OF AIR CONDUCTION REGIONS

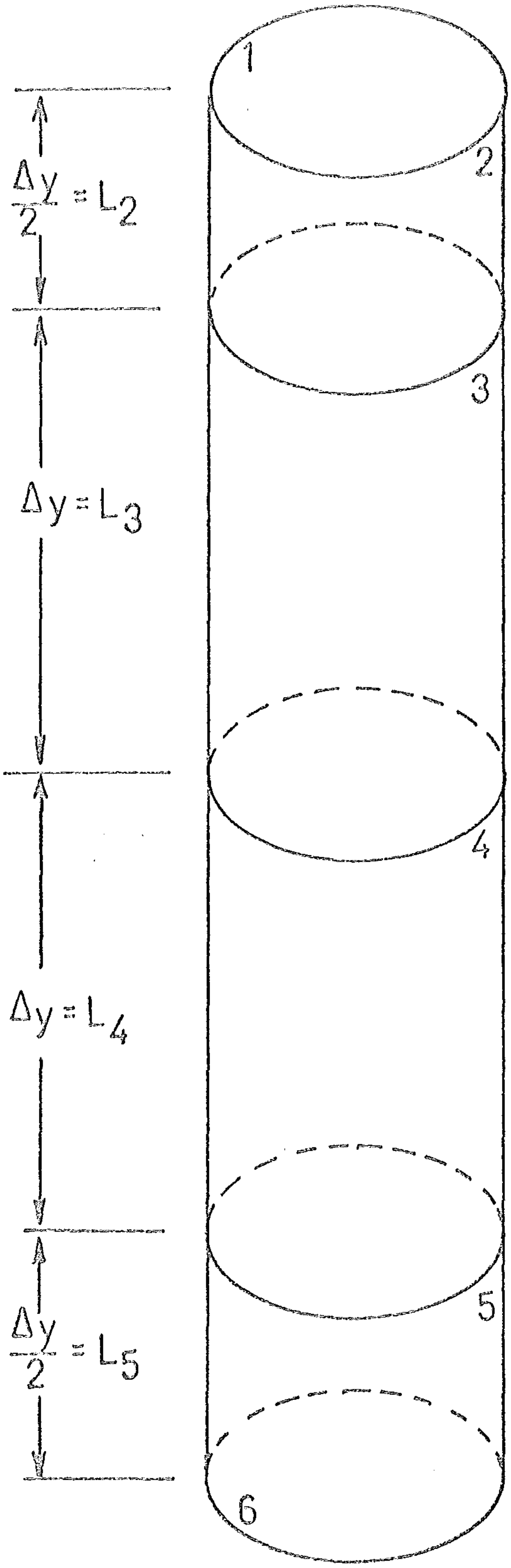


FIGURE B9 HOLE DRILLED IN BLOCK OF SPECIMEN SHOWING RADIATION REGIONS (aluminium cold and hot plates). The rest of the regions are ring regions (Figure B9). Each radiation region has a 'radiation-region' temperature (TR(I)) associated with it. The surface nodal points in each radiation region are shown in Figure B6.

The radiation flow to each surface point is QRAD(I,J). where J is the radiation region number

I is the surface point counter

That is:

(a) for surface points 6, 19, 32, 45 and 58: J = 2, whereas I = 1, 2, 3, 4 and 5 respectively

(b) for surface points 132, 145, 158, 171 and 184: J = 3, whereas I = 1, 2, 3, 4 and 5 respectively

(c) similarly, for surface points in regions 4 and 5, J = 4 and 5 respectively

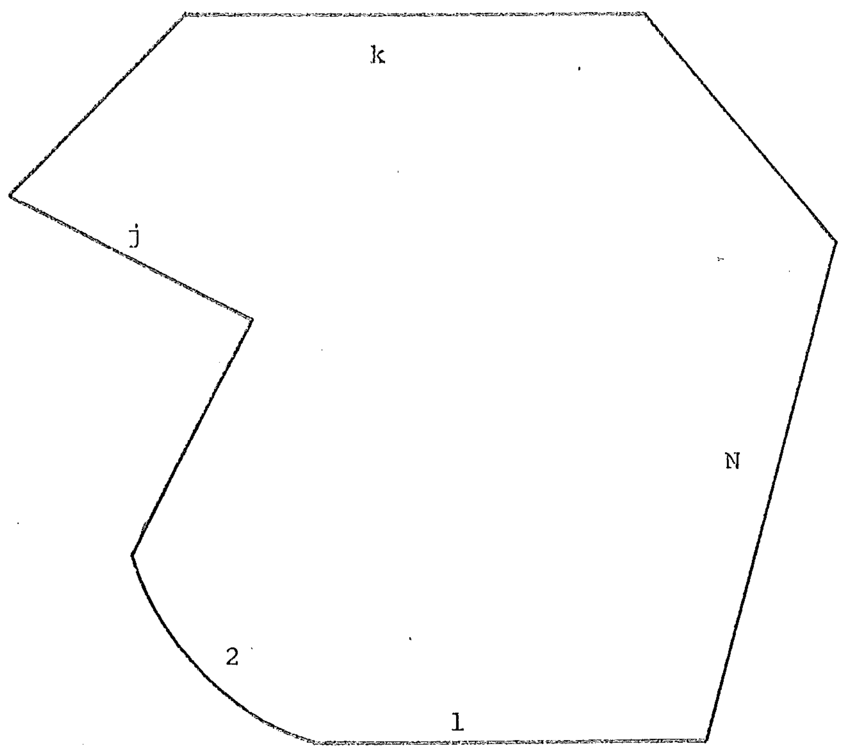
B2.3 AIR CONDUCTION ZONES

In the hole, the air contained within was divided into isothermal regions. Figure B8 shows the 2mm diameter constant temperature air core in the centre of the hole, and the two radial air regions - one at surface point temperatures and the other at intermediate temperatures between the air core temperature and the surface temperatures. In the y-direction, the air regions corresponded exactly to the solid conduction regions (Figure B7).

B3 NET RADIATION METHOD

Consider an enclosure composed of N discrete surface areas as shown in Figure B10. The objective of the analysis is to analyse the radiation exchange between the surface areas.

(A) Enclosure Composed Of N Discrete Surface Areas With Typical Surfaces j and k



(B) Energy Quantities Incident Upon And Leaving Typical Surface Of Enclosure

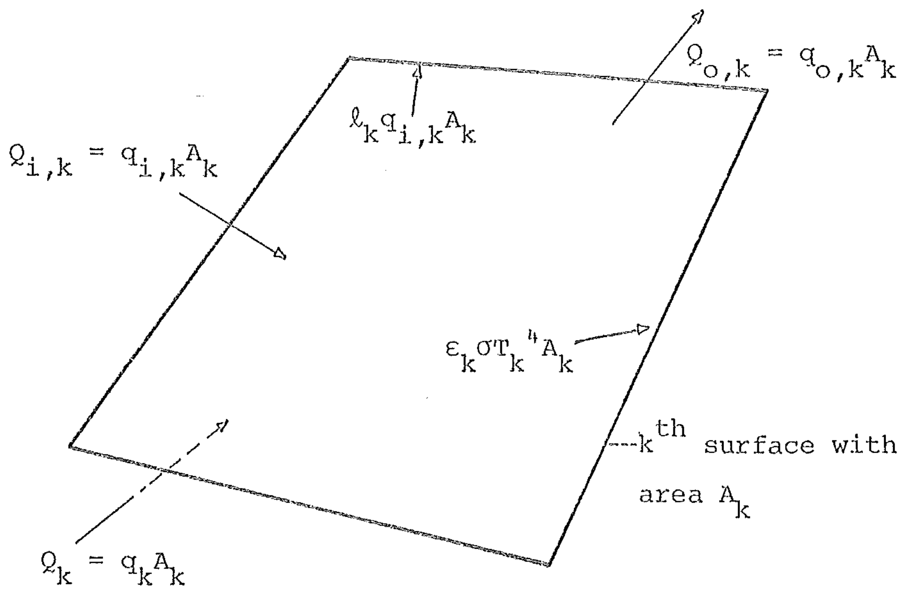


FIGURE B10 RADIATION BETWEEN FINITE AREAS

Two types of boundary conditions can be used with this method.

(a) the required energy supplied to a surface is to be determined when the surface temperature is specified

(b) the temperature that a surface will achieve is to be found when a known heat input is imposed

In this work, boundary conditions of type 'a' were used.

Consider the kth inside surface area A_k of the enclosure shown in Figure B10. The quantities q_i and q_o are the rates of incoming and outgoing radiant energy per unit area, respectively. The quantity q is the energy flux supplied by some external means to the surface to make up for the net radiative loss and thereby maintain the specified surface temperature. A heat balance at the surface provides the relation:

$$Q_k = q_k A_k = (q_{o,k} - q_{i,k})\ A_k \tag{B-1}$$

A second equation results from the fact that the energy flux leaving the surface is composed of directly emitted plus reflected energy. This gives:

$$\begin{aligned} q_{o,k} &= \varepsilon_k \sigma T_k + \ell_k q_{i,k} \\ &= \varepsilon_k \sigma T_k + (1-\varepsilon_k)\ q_{i,k} \end{aligned} \tag{B-2}$$

where $\ell_k = 1 - \alpha_k = 1 - \varepsilon_k$ (assuming opaque gray surfaces)

q_o is the radiosity

The incident flux $q_{i,k}$ is derived from the portions of the energy leaving the surfaces in the enclosure that arrive at the kth surface. The incident flux is equal to:

$$A_k q_{i,k} = A_1 q_{o,1} F_{1-k} + A_2 q_{o,2} F_{2-k} + \ldots\ldots + \ldots\ldots$$
$$\ldots + A_j q_{o,j} F_{j-k} + \ldots\ldots + A_k q_{o,k} F_{k-k} + \ldots\ldots$$
$$+ A_N q_{o,N} F_{N-k} \qquad \text{(B-3)}$$

From the configuration-factor reciprocity relation,

$$A_1 F_{1-k} = A_k F_{k-1}$$
$$A_2 F_{2-k} = A_k F_{k-2}$$
$$\vdots \qquad \vdots$$
$$A_N F_{N-k} = A_k F_{k-N} \qquad \text{(B-4)}$$

Then equation B-3 can be written so that the only area appearing is A_k.

$$A_k q_{i,k} = A_k F_{k-1} q_{o,1} + A_k F_{k-2} q_{o,2} + \ldots\ldots + A_k F_{k-j} q_{o,j} +$$
$$\ldots\ldots + \ldots\ldots + A_k F_{k-k} q_{o,k} + \ldots\ldots +$$
$$A_k F_{k-N} q_{o,N} \qquad \text{(B-5)}$$

or $$q_{i,k} = \sum_{j=1}^{N} F_{k,j} q_{o,j} \qquad \text{(B-6)}$$

Equations B-2 and B-6 provide two different expressions for $q_{i,k}$. These are each substituted into equation B-1 to eliminate $q_{i,k}$ and provide two basic heat balance equations for Q_k in terms of $q_{o,k}$.

$$Q_k = \frac{A_k \varepsilon_k}{(1-\varepsilon_k)} (\sigma T_k^{\,4} - q_{o,k}) \qquad \text{(B-7)}$$

$$Q_k = A_k (q_{o,k} - \sum_{j=1}^{N} F_{k-j} q_{o,j}) \qquad \text{(B-8)}$$

where Q_k can be regarded as either the energy supplied to the surface k by external means or the net radiative loss from surface k resulting from radiation in the enclosure.

Equations B-7 and B-8 can be written for each of the N surfaces in the enclosure. This provides 2N equations for 2N unknowns. The q's are N of the unknowns. The remaining unknowns consist of the Q's.

B3.1 SOLUTION METHOD

Computing the radiative exchange within an enclosure involves first solving for q_o for each surface and then computing the Q's.

When the surface temperatures are all specified, the set of simultaneous equations for q_o's is obtained by eliminating Q_k's from B-7 and B-8. This yields the following equation for the kth surface.

$$q_{o,k} - (1-\varepsilon_k)\sum_{j=1}^{N} F_{k-j} q_{o,j} = \varepsilon_k \sigma T_k^{4} \qquad \text{(B-9)}$$

an alternate form of this equation is:

$$\sum_{j=1}^{N} \{\delta_{kj} - (1-\varepsilon_k) F_{k-j}\} q_{o,j} = \varepsilon_k \sigma T_k \qquad \text{(B-10)}$$

where δ_{kj} is the Kronecker delta symbol:

$$\delta_{kj} = 0 \quad \text{when } k \neq j$$
$$= 1 \quad \text{when } k = j$$

With the T's known, the q_o's can be found from B-10. Equation B-7 is then used to compute the Q's.

B3.2 METHOD OF SOLUTION (USED IN THIS WORK)

From Figure B9, N = 6. The matrix of outgoing radiative flux (q_o) is derived from equation B-10.

Matrix Of The Radiosities - Equation B-11

$$\{1-(1-\varepsilon_1)F_{1-1}\}q_{o,1}-(1-\varepsilon_1)F_{1-2}q_{o,2}-(1-\varepsilon_1)F_{1-3}q_{o,3}-(1-\varepsilon_1)F_{1-4}q_{o,4}-(1-\varepsilon_1)F_{1-5}q_{o,5}-(1-\varepsilon_1)F_{1-6}q_{o,6} = \varepsilon_1\sigma T_{r1}^4$$

$$-(1-\varepsilon_1)F_{2-1}q_{o,1}+\{1-(1-\varepsilon_2)F_{2-2}\}q_{o,2}-(1-\varepsilon_2)F_{2-3}q_{o,3}-(1-\varepsilon_2)F_{2-4}q_{o,4}-(1-\varepsilon_2)F_{2-5}q_{o,5}-(1-\varepsilon_2)F_{2-6}q_{o,6} = \varepsilon_2\sigma T_{r2}^4$$

$$-(1-\varepsilon_3)F_{3-1}q_{o,1}-(1-\varepsilon_3)F_{3-2}q_{o,2}+\{1-(1-\varepsilon_3)F_{3-3}\}q_{o,3}-(1-\varepsilon_3)F_{3-4}q_{o,4}-(1-\varepsilon_3)F_{3-5}q_{o,5}-(1-\varepsilon_3)F_{3-6}q_{o,6} = \varepsilon_3\sigma T_{r3}^4$$

$$-(1-\varepsilon_4)F_{4-1}q_{o,1}-(1-\varepsilon_4)F_{4-2}q_{o,2}-(1-\varepsilon_4)F_{4-3}q_{o,3}+\{1-(1-\varepsilon_4)F_{4-4}\}q_{o,4}-(1-\varepsilon_4)F_{4-5}q_{o,5}-(1-\varepsilon_4)F_{4-6}q_{o,6} = \varepsilon_4\sigma T_{r4}^4$$

$$-(1-\varepsilon_5)F_{5-1}q_{o,1}-(1-\varepsilon_5)F_{5-2}q_{o,2}-(1-\varepsilon_5)F_{5-3}q_{o,3}-(1-\varepsilon_5)F_{5-4}q_{o,4}+\{1-(1-\varepsilon_5)F_{5-5}\}q_{o,5}-(1-\varepsilon_5)F_{5-6}q_{o,6} = \varepsilon_5\sigma T_{r5}^4$$

$$-(1-\varepsilon_6)F_{6-1}q_{o,1}-(1-\varepsilon_6)F_{6-2}q_{o,2}-(1-\varepsilon_6)F_{6-3}q_{o,3}-(1-\varepsilon_6)F_{6-4}q_{o,4}-(1-\varepsilon_6)F_{6-5}q_{o,5}+\{1-(1-\varepsilon_6)F_{6-6}\}q_{o,6} = \varepsilon_6\sigma T_{r6}^4$$

B4 SHAPE FACTORS

For a cylinder divided into rings and discs, shape factors are of three basic configurations (Figure B9).

(a) from any ring to another e.g. F_{2-3}

(b) from any ring to any disc e.g. F_{3-1}

(c) from any disc to another disc e.g. F_{1-6}

Leuenberger (165) developed shape factors for cylindrical assemblies encompassing the above three configurations. By using flux algebra and Leuenberger's formulas, 'statement functions' were set up in Fortran IV to evaluate the shape factors for the various linear dimensions of the cavity problem simulations. The basic expressions used are given below (all referring to Figure B9).

B4.1 SHAPE FACTORS OF RING TO RING

The general formula for the shape factor of one ring surface 'a' to another 'b' is:

$$F_{a-b} = \frac{L_b}{2R} + \frac{1}{4}\{(\sqrt{(4+\frac{L_b^2}{R^2})}) + \frac{L_b}{L_a}(\sqrt{(4+\frac{L_b^2}{R^2})}) - (\frac{L_a+L_b}{L_a})$$

$$(\sqrt{(4+(\frac{L_a+L_b}{R})^2)})\} \qquad (B-12)$$

where R is the radius of the cylinder.

(1) <u>Computing F_{2-3}</u>

$$F_{2-3} = F_{5-4}$$

Put $L_a = L_2$

$L_b = L_3$ and then substitute into B-12

(2) Computing F_{2-4}

$F_{2-4} = F_{5-3}$

First compute $F_{2-(3+4)}$, that is,

Put $L_a = L_2$

$L_b = L_3 + L_4$

But $F_{2-(3+4)} = F_{2-3} + F_{2-4}$

Since F_{2-3} is known from (1)

Then $F_{2-4} = F_{2-(3+4)} - F_{2-3}$

(3) Computing F_{2-5}

Again compute $F_{2-(3+4+5)}$ first

That is, put $L_a = L_2$

$L_b = L_3 + L_4 + L_5$

Since $F_{2-(3+4+5)} = F_{2-3} + F_{2-4} + F_{2-5}$

Then F_{2-5} is known

(4) Computing F_{3-4}

$F_{3-4} = F_{4-3}$

Put $L_a = L_3$ and $L_b = L_4$

Substitute into B-12

B4.2 SHAPE FACTORS OF DISC TO RING

Starting with the top disc, that is, region 1, the shape factors of a disc surface to a ring surface are F_{1-2}, F_{1-3}, F_{1-4}, and F_{1-5}. By symmetry, these are equal to those from region 6, that is, F_{6-5}, F_{6-4}, F_{6-3}, and F_{6-2} respectively.

The general expression for the shape factor of a disc surface 'a' to a ring surface 'b' is:

$$F_{a-b} = \frac{1}{2}\left(\frac{L_b}{R}\left(\sqrt{\left(4+\frac{L^2_b}{R^2}\right)} - \frac{L^2_b}{R^2}\right)\right) \qquad \text{(B-13)}$$

(1) <u>Computing F_{1-2}</u>

Put $L_b = L_2$ and substitute into B-13

(2) <u>Computing F_{1-3}</u>

Put $L_b = L_2 + L_3$ and hence compute $F_{1-(2+3)}$

$F_{1-(2+3)} = F_{1-2} + F_{1-3}$

Since F_{1-2} is known from (1), then F_{1-3} can be found

(3) <u>Computing F_{1-4}</u>

Put $L_b = L_2 + L_3 + L_4$ and hence compute $F_{1-(2+3+4)}$

From (1), (2) and flux algebra,

$F_{1-4} = F_{1-(2+3+4)} - F_{1-2} - F_{1-3}$

(4) <u>Computing F_{1-5}</u>

Put $L_b = L_2 + L_3 + L_4 + L_5$

Hence $F_{1-5} = F_{1-(2+3+4+5)} - F_{1-2} - F_{1-3} - F_{1-4}$

B4.3 SHAPE FACTORS OF DISC TO DISC

The equation used for the shape factors of a disc surface ('1') to another ('6') is:

$$F_{1-6} = F_{6-1} = 1 - \frac{1}{2}\left(\frac{L}{R}\sqrt{\left(4+\frac{L^2}{R^2}\right)} - \frac{L^2}{R^2}\right) \qquad \text{(B-14)}$$

where $L = L_2 + L_3 + L_4 + L_5$ (thickness of specimen)

B4.4 SHAPE FACTORS OF SURFACE k TO SURFACE k

If the kth surface can view itself (is concave), it will intercept a portion of its own emitted energy. The configuration factor F_{k-k} is evaluated from equation B-15 after all the other factors are known.

$$F_{k-1} + F_{k-2} + F_{k-3} + \ldots\ldots + F_{k-k} + \ldots\ldots + F_{k-N} = 1 \qquad \text{(B-15)}$$

B5 THERMAL CONDUCTANCES

The thermal conductances are calculated using the basic formula:

$$K_{ij} = k\frac{A_{ij}}{L_{ij}} \qquad \text{(B-16)}$$

where k = thermal conductivity

A_{ij} = average surface area perpendicular to the direction of heat flow

L_{ij} = distance between the nodes

B5.1 SOLID CONDUCTION REGION (INTERIOR)

In Figure B3, consider nodal point 201 (diameter of hole = 35.5mm).

$$CXY(201) = \frac{k \times 2.027 \times \Delta y}{2.690} \qquad \text{(B-17)}$$

where CXY = conductance in the x-direction

Δy = depth of zone of constant temperature Figure B1

2.027×10^{-3} metres = width of the zone associated with point 201

2.690×10^{-3} metres = distance between nodal points 201 and 202

Similarly, if considering the conductance in the y-direction

$$CYX(201) = \frac{k \times 2.879 \times 2.027}{\Delta y} \qquad (B-18)$$

with Δy as the distance between nodal points 201 and 75

In the z-direction, the conductance associated with point 201 is:

$$CZX(201) = \frac{k \times 3.404 \times \Delta y}{2.027} \qquad (B-19)$$

with 2.027×10^{-3} metres as the distance between nodal points 201 and 215

B5.2 SOLID CONDUCTION REGION (BOUNDARY NODES)

For irregular boundaries, the rectangular network formulas used for the interior nodes are not applicable. The irregular boundaries occurred at the air-solid interface, points such as 132, 145, 158, 171 and 184 in Figure B3. The thermal conductances associated with these points were evaluated using the unified method due to Macneal (117).

In Figure B3, the conductance between nodal points 132 and 146 is:

$$CZX\ (132) = \frac{k(\text{Cot } B_1 + \text{Cot } B_2)\Delta y}{2} \qquad (B-20)$$

This type of equation was used for all the other surface points. For example,

$$CZX(284) = k\ \frac{\left(\frac{3.30}{1.10} + \frac{3.068}{1.01}\right)}{2}\Delta y \qquad (B-21)$$

Before accepting Macneal's method, a geometrical proof of the validity of the method was done.

B5.3 AIR CONDUCTANCES

The conductances between the various air nodal points in the hole (Figure B8) were evaluated using equation B-22.

$$K_{ij} = 2\pi k L_{ij}/\ln\ (r_o/r_i) \qquad \text{(B-22)}$$

B6 NODAL EQUATIONS

For the nodal points shown in Figures B3 and B4, one general relaxation equation was derived. This equation (B-23) was derived by considering the heat balance of a general point. The numbering system used refers to the nodal points shown in Figures B2 to B5.

For surface points, some of the conductances are used for storing the convergence variable, that is, dQ_r/dT. For example,

CXY(132) = -DQDT(1,3)

CXY(144) = -DQDT(2,3)

CZX(144) = -DQDT(3,3)

See the computer listing for more details.

$$\frac{\begin{array}{l}\mathrm{CRAD(I)+(CXY(I-1)T(I-1))+(CXY(I)T(I+1))+(CYX(I+126)T(I+}\\ \mathrm{126))+(CYX(I)T(I-126))+(CZX(I-14)T(I-14))+(CZX(I)T(I+14)}\end{array}}{\mathrm{(CXY(I-1)+CXY(I)+CYX(I+126)+CYX(I)+CZX(I-14)+CZX(I))}} - \mathrm{T(I)} = \mathrm{RES(I)} \tag{B-23}$$

where CRAD(I) = radiation heat flow for surface points (points like 132, 145, 297, 284)

= 0 for interior points (solid conduction points)

T = the temperature in degrees Celsius

CXY, CYX, CZX = the conductances

RES(I) = residual of the equation which is evaluated until it becomes negligible in magnitude e.g. 10^{-5}

B7 NOTES ON SPECIMENS USED

Durotherm (asbestos cement board) is opaque. Perspex, however, has a transmittance of 92% in the wavelength range 0.335 microns to 1.6 microns (146). No data was found in the wavelength range 2 to 20 microns. In the range 20 to 100 microns, the transmittance is about 20%.

Assuming that perspex transmits 92% of the incident radiation in the wavelength range 0.335 to 1.6 microns, and is opaque at shorter and longer wavelengths, the percentage of incident radiation from a blackbody at a specified temperature which perspex will transmit can be estimated.

(i) Specimen temperature of $44^{\circ}C$ - from radiation functions tables (166) (and also a computer program evaluating radiation function polynomials), the percentage of the total radiant energy incident upon perspex was:

$$\{(0.166 \times 10^{-8})\% - (0.615 \times 10^{-53})\%\} \times 0.92 = 0\%$$

(ii) Specimen temperature of $60^{\circ}C$

$$\lambda T_{lower} = 0.335 \times 600 = 201 \text{ (microns, } ^{O}R)$$

$$\lambda T_{upper} = 1.59 \times 600 = 954 \text{ (microns, } ^{O}R)$$

From the computer program (which is not given in this work)

$$\frac{\int_0^{0.335} E_{b\lambda}\, d\lambda}{\int_0^{\infty} E_{b\lambda}\, d\lambda} = 0.37 \times 10^{-50}\%$$

and

$$\frac{\int_{0}^{1.59} E_{b\lambda}\, d\lambda}{\int_{0}^{\infty} E_{b\lambda}\, d\lambda} = 0.5578 \times 10^{-8}\%$$

The amount of energy transmitted is:

$((0.56 \times 10^{-8}) - (0.37 \times 10^{-50})) \times .92 = 0\%$

The transmittance data used in the above calculations was for 3.2mm thick lucite. Plexiglas plate 4.93mm thick gave a transmittance of 0% in the wavelength range 20 to 100 microns (146). Since all the specimens used in this work were 5.6mm thick or more, it was assumed that all incident radiation in the perspex specimens was absorbed. With a scattering coefficient of less than 0.01cm^{-1} (151), the scattering of radiation in the perspex specimens was also ignored. Note that a scattering coefficient of 0.01cm^{-1} implies that the mean free path before scattering starts is equal to 100cm.

CONCLUDING REMARKS - The perspex specimens used are of sufficient thickness to ensure that all the incident radiation is absorbed and they can be considered to be opaque.

APPENDIX C

SURFACE TEMPERATURE SIMULATIONS

C1 EVALUATION OF CONDUCTANCES

The formulae used in Appendix B are applicable. Due to the presence of the three different materials (perspex, araldite and aluminium), composite media formulae had to be applied. The total conductances between isothermal faces were obtained by adding the individual parallel conductances. When conductances were in series, the total conductance was set equal to the sum of the reciprocal of the individual conductances. Consider for example, the structure shown in Figure C1.

The faces AB and CD are at constant temperatures; therefore, they can be represented by two nodes, say 1 and 2. Consider the auxiliary nodes a, b, c, d, e and f. The total conductance between nodes 1 and 2 is:

$$K_{1,2} = K_{a,b} + K_{c,d} + K_{e,f} \qquad \text{(C-1)}$$

where
$$\frac{1}{K_{a,b}} = \frac{L_1}{\ell_1 k_1} + \frac{L_2}{\ell_1 k_2} \qquad \text{(C-2)}$$

$$K_{c,d} = \frac{k_1 \ell_2}{L_1 + L_2} \qquad \text{(C-3)}$$

$$K_{e,f} = \frac{k_3 \ell_3}{L_1 + L_2} \qquad \text{(C-4)}$$

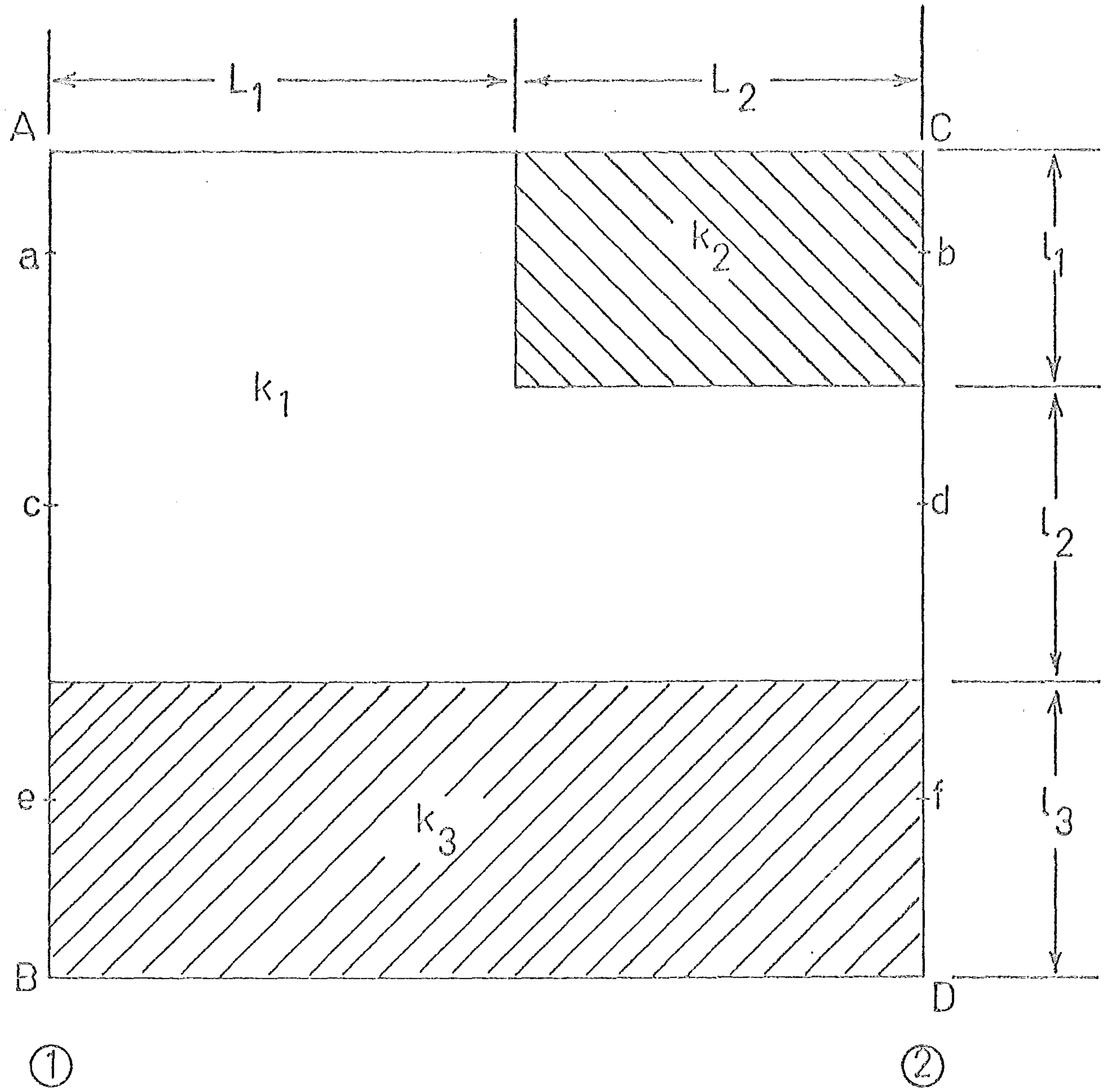


FIGURE C1—COMPOSITE SYSTEM

C2 GENERAL GRID SYSTEM

Figure C2 shows a general grid system. The three thermocouple grooves are expanded in size to show the nodal points. Since aluminium has a much higher thermal conductivity than araldite, despite their size, the thermocouple grooves always had more nodal points. Similarly, in the specimen region, nodal points were more numerous than in the aluminium region.

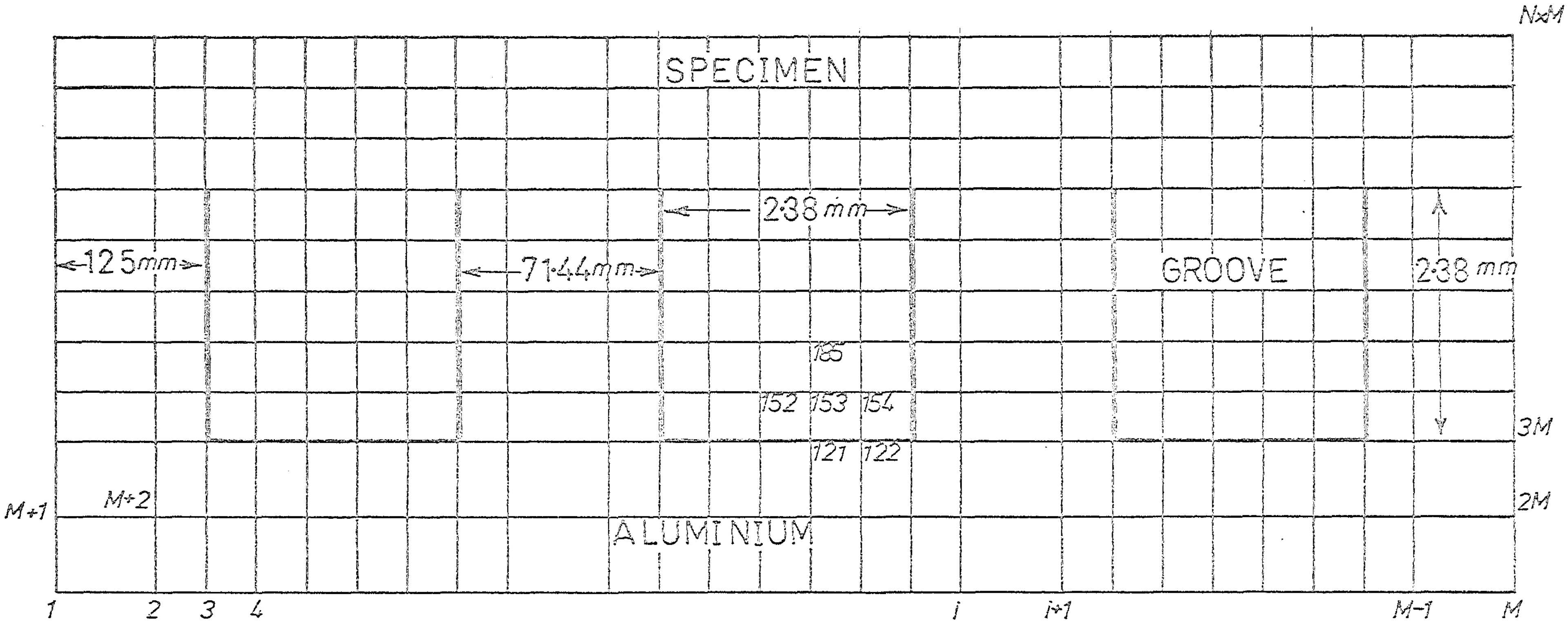


FIGURE C2–A TYPICAL NODAL SYSTEM —— SURFACE TEMPERATURE SIMULATIONS

C3 TEMPERATURE PROFILES OF SIMULATION RUNS 1 TO 10

The temperature profiles of the surface temperature simulation runs described in Chapter 1 are shown in Tables C1 to C10.

TABLE C1

Temperature profile of surface temperature simulation run 1 showing the 1 groove configuration with a 3mm x 4mm aluminium insert in the groove

10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	110000	10000
9985	9985	9985	9985	9986	9986	9987	9989	9991	9992	9992	9991	9989	9987	9986	9986	9985	9985	9985	9985
9971	9971	9971	9971	9971	9972	9974	9977	9982	9984	9984	9982	9977	9974	9972	9971	9971	9971	9971	9971
9956	9956	9956	9956	9956	9957	9959	9965	9975	9979	9979	9975	9965	9959	9957	9956	9956	9956	9956	9956
9941	9941	9941	9941	9941	9941	9941	9940	9125	9120	9120	9124	9940	9940	9940	9941	9941	9941	9941	9941
9927	9927	9926	9926	9925	9924	9922	9920	9117	9115	9114	9117	9920	9922	9924	9925	9926	9926	9927	9927
9912	9912	9912	9911	9910	9908	9905	9902	9108	9106	9106	9108	9902	9905	9908	9910	9911	9912	9912	9912
9898	9898	9898	9897	9895	9892	9888	9883	9097	9096	9096	9097	9883	9888	9892	9895	9897	9898	9898	9898
9885	9885	9884	9883	9881	9878	9872	9861	9083	9084	9084	9082	9861	9872	9878	9881	9883	9884	9885	9885
7256	7256	7255	7253	7247	7235	7203	7115	6859	6785	6785	6859	7115	7202	7235	7247	7253	7255	7256	7256
4628	4628	4627	4625	4621	4611	4588	4539	4453	4413	4413	4453	4539	4588	4611	4621	4625	4627	4628	4628
2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000

TABLE C2

Temperature profile of surface temperature simulation run 2 showing the 1 groove configuration with a 4.99mm x 4mm aluminium insert in the groove

10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
9985	9985	9985	9985	9985	9985	9986	9988	9991	9992	9992	9991	9988	9986	9985	9985	9985	9985	9985	9985
9969	9969	9969	9969	9970	9970	9972	9976	9982	9986	9986	9982	9976	9972	9970	9970	9969	9969	9969	9969
9954	9954	9954	9954	9954	9954	9955	9961	9977	9983	9983	9977	9961	9955	9954	9954	9954	9954	9954	9954
9939	9939	9939	9938	9938	9936	9934	9928	9900	9893	9893	9900	9928	9934	9936	9938	9938	9939	9939	9939
9924	9924	9924	9923	9922	9920	9917	9911	9894	9889	9889	9894	9911	9917	9920	9922	9923	9924	9924	9924
9910	9910	9909	9908	9907	9904	9901	9896	9884	9881	9881	9884	9896	9901	9904	9907	9908	9909	9910	9910
9896	9896	9895	9894	9892	9890	9886	9882	9871	9869	9869	9871	9882	9886	9890	9892	9894	9895	9896	9896
9882	9882	9882	9881	9879	9876	9873	9868	9853	9855	9855	9853	9868	9873	9876	9879	9881	9882	9882	9882
7255	7255	7254	7253	7252	7250	7248	7244	7239	7238	7238	7239	7244	7248	7250	7252	7253	7254	7255	7255
4627	4627	4627	4627	4626	4625	4624	4622	4620	4619	4619	4620	4622	4624	4625	4626	4627	4627	4627	4627
2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000

TABLE C3

Temperature profile of surface temperature

simulation run 3 showing the 1 groove configuration

4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514
4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514
4514	4514	4513	4513	4513	4513	4513	4513	4514	4514	4514	4514	4513	4513	4513	4513	4513	4513	4514	4514
4513	4513	4513	4513	4513	4513	4513	4513	4513	4514	4514	4513	4513	4513	4513	4513	4513	4513	4513	4513
4513	4513	4513	4512	4512	4512	4512	4512	4511	4510	4510	4511	4512	4512	4512	4512	4512	4513	4513	4513
4512	4512	4512	4511	4511	4512	4512	4512	4508	4506	4506	4508	4512	4512	4512	4511	4511	4512	4512	4512
4511	4511	4510	4510	4511	4511	4511	4511	4504	4499	4499	4504	4511	4511	4511	4511	4510	4510	4511	4511
4507	4507	4508	4509	4510	4511	4511	4511	4496	4488	4488	4496	4511	4511	4511	4510	4509	4508	4507	4507
4496	4496	4505	4508	4510	4510	4511	4511	4481	4470	4470	4481	4511	4511	4510	4510	4508	4505	4496	4496
4442	4442	4454	4459	4461	4462	4461	4458	4447	4441	4441	4447	4458	4461	4462	4461	4459	4454	4442	4442
4403	4403	4409	4413	4414	4414	4414	4412	4408	4406	4406	4408	4412	4414	4414	4414	4413	4409	4403	4403
4366	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368

TABLE C4

Temperature profile of surface temperature

simulation run 4 showing the 1 groove configuration

using constant temperature boundary conditions

4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514
4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514
4514	4514	4513	4513	4513	4513	4513	4513	4514	4514	4514	4514	4513	4513	4513	4513	4513	4513	4514	4514
4513	4513	4513	4513	4513	4513	4513	4513	4513	4514	4514	4513	4513	4513	4513	4513	4513	4513	4513	4513
4513	4513	4513	4512	4512	4512	4512	4512	4511	4511	4511	4511	4512	4512	4512	4512	4512	4513	4513	4513
4512	4512	4512	4511	4511	4512	4512	4512	4509	4507	4507	4509	4512	4512	4512	4511	4511	4512	4512	4512
4511	4511	4510	4510	4511	4511	4511	4511	4506	4502	4502	4506	4511	4511	4511	4511	4510	4510	4511	4511
4507	4507	4508	4509	4510	4511	4511	4511	4500	4494	4494	4500	4511	4511	4511	4510	4509	4508	4507	4507
4496	4496	4505	4508	4510	4510	4511	4511	4489	4481	4481	4489	4511	4511	4510	4510	4508	4505	4496	4496
4442	4442	4454	4459	4461	4462	4461	4459	4451	4447	4447	4451	4459	4461	4462	4461	4459	4454	4442	4442
4403	4403	4409	4413	4414	4415	4414	4413	4410	4408	4408	4410	4413	4414	4415	4414	4413	4409	4403	4403
4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368	4368

TABLE C5

Temperature profile of surface temperature

simulation run 5 showing the 1 groove configuration

4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514
4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514
4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513
4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513
4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513
4512	4512	4512	4512	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513
4512	4512	4512	4512	4512	4512	4512	4512	4512	4513	4513	4513	4512	4512	4512	4512	4512	4512	4512	4512
4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512
4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512
4512	4512	4512	4512	4512	4512	4512	4512	4511	4511	4511	4512	4512	4512	4512	4512	4512	4512	4512	4512
4511	4511	4512	4512	4512	4512	4512	4512	4511	4510	4510	4511	4512	4512	4512	4512	4512	4512	4512	4512
4511	4511	4511	4511	4511	4511	4511	4512	4509	4508	4508	4509	4512	4512	4512	4512	4512	4512	4512	4512
4511	4511	4511	4511	4511	4511	4511	4511	4507	4505	4505	4507	4513	4512	4512	4512	4512	4512	4512	4512
4511	4511	4511	4511	4511	4511	4511	4511	4503	4500	4500	4503	4511	4512	4512	4512	4512	4512	4512	4512
4495	4495	4495	4495	4494	4494	4494	4493	4490	4488	4488	4490	4493	4494	4494	4495	4495	4495	4495	4495
4478	4478	4478	4478	4478	4477	4477	4476	4475	4474	4474	4475	4476	4477	4478	4478	4478	4478	4478	4478
4462	4462	4461	4461	4461	4461	4460	4460	4459	4459	4459	4459	4460	4461	4461	4461	4462	4462	4462	4462
4445	4445	4445	4445	4445	4445	4444	4444	4443	4443	4443	4443	4444	4444	4445	4445	4445	4445	4445	4445
4429	4429	4429	4429	4429	4428	4428	4428	4428	4427	4427	4428	4428	4425	4428	4429	4429	4429	4429	4429
4413	4413	4412	4412	4412	4412	4412	4412	4412	4412	4412	4412	4412	4412	4412	4412	4413	4413	4413	4413
4396	4396	4396	4396	4396	4396	4396	4396	4396	4396	4396	4396	4395	4396	4396	4396	4396	4396	4397	4397
4380	4380	4380	4380	4380	4380	4380	4380	4380	4380	4380	4380	4380	4380	4380	4380	4380	4380	4380	4380
4364	4364	4364	4364	4364	4364	4364	4364	4364	4364	4364	4364	4364	4364	4364	4364	4364	4364	4364	4364
4348	4348	4348	4348	4348	4348	4348	4348	4348	4348	4348	4348	4348	4346	4348	4348	4348	4348	4348	4348
4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332
4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316
4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300

TABLE C6

Temperature profile of surface temperature

simulation run 6 showing the ideal temperature profile

4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514
4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513	4513
4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4513	4513	4513	4513	4513	4513
4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512	4512
4511	4511	4511	4511	4511	4511	4511	4511	4511	4511	4511	4511	4511	4511	4511	4511	4511	4511	4511	4511
4510	4510	4510	4510	4510	4510	4510	4510	4510	4510	4510	4510	4510	4510	4511	4511	4511	4511	4511	4511
4510	4510	4510	4510	4510	4510	4510	4510	4510	4510	4510	4510	4510	4510	4510	4510	4510	4510	4510	4510
4509	4509	4509	4509	4509	4509	4509	4509	4509	4509	4509	4509	4509	4509	4509	4509	4510	4510	4510	4510
4509	4509	4509	4509	4509	4509	4509	4509	4509	4509	4509	4509	4509	4509	4509	4509	4509	4509	4509	4509
4506	4508	4508	4508	4508	4508	4508	4508	4508	4508	4509	4509	4509	4509	4509	4509	4509	4509	4509	4509
4506	4508	4508	4508	4508	4508	4506	4508	4508	4508	4508	4508	4508	4508	4508	4508	4509	4509	4509	4509
4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508
4505	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508
4506	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508	4508
4491	4491	4491	4491	4491	4491	4491	4491	4491	4492	4492	4492	4492	4492	4492	4492	4492	4492	4492	4492
4475	4475	4475	4475	4475	4475	4475	4475	4475	4475	4475	4475	4475	4475	4475	4475	4476	4476	4476	4476
4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459	4459
4443	4443	4443	4443	4443	4443	4443	4443	4443	4443	4443	4443	4443	4443	4443	4443	4443	4443	4443	4443
4427	4427	4427	4427	4427	4427	4427	4427	4427	4427	4427	4427	4427	4427	4427	4427	4427	4427	4427	4427
4411	4411	4411	4411	4411	4411	4411	4411	4411	4411	4411	4411	4411	4411	4411	4411	4411	4411	4411	4411
4395	4395	4395	4395	4395	4395	4395	4395	4395	4395	4395	4395	4395	4395	4395	4395	4395	4395	4395	4395
4379	4379	4379	4379	4379	4379	4379	4379	4379	4379	4379	4379	4379	4379	4379	4379	4379	4379	4379	4379
4363	4363	4363	4363	4363	4363	4363	4363	4363	4363	4363	4363	4363	4363	4363	4363	4363	4363	4363	4363
4347	4347	4347	4347	4347	4347	4347	4347	4347	4347	4347	4347	4347	4347	4347	4347	4347	4347	4348	4348
4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332	4332
4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316	4316
4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300

TABLE C7

Temperature profile of surface temperature simulation run 7 showing the 1 deep narrow groove configuration

4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514
4504	4504	4504	4504	4504	4504	4505	4505	4505	4506	4506	4505	4505	4505	4504	4504	4504	4504	4504	4504
4493	4493	4493	4493	4494	4494	4495	4496	4498	4498	4498	4498	4496	4495	4494	4494	4493	4493	4493	4493
4482	4482	4482	4483	4483	4484	4485	4488	4492	4494	4494	4492	4488	4485	4484	4483	4483	4482	4482	4482
4472	4472	4472	4472	4472	4472	4472	4473	4475	4475	4475	4475	4473	4472	4472	4472	4472	4472	4472	4472
4461	4461	4461	4461	4461	4461	4461	4461	4461	4462	4462	4461	4461	4461	4461	4461	4461	4461	4461	4461
4451	4451	4451	4451	4451	4450	4450	4450	4450	4450	4450	4450	4450	4450	4450	4451	4451	4451	4451	4451
4442	4442	4442	4442	4441	4441	4441	4441	4441	4441	4441	4441	4441	4441	4441	4441	4442	4442	4442	4442
4435	4435	4434	4434	4434	4433	4433	4433	4433	4432	4432	4433	4433	4433	4433	4434	4434	4434	4435	4435
4428	4428	4428	4427	4427	4427	4426	4426	4426	4426	4426	4426	4426	4426	4427	4427	4427	4428	4428	4428
4423	4423	4423	4422	4422	4422	4421	4421	4421	4420	4420	4421	4421	4421	4422	4422	4422	4423	4423	4423
4419	4419	4419	4419	4418	4418	4418	4417	4417	4416	4416	4417	4417	4418	4418	4418	4419	4419	4419	4419
4417	4417	4417	4417	4416	4416	4415	4415	4414	4413	4413	4414	4415	4415	4416	4416	4417	4417	4417	4417
4417	4417	4416	4416	4416	4415	4415	4415	4411	4409	4409	4411	4415	4415	4415	4416	4416	4416	4417	4417
4400	4400	4400	4399	4399	4398	4398	4397	4396	4395	4395	4396	4397	4398	4398	4399	4399	4400	4400	4400
4385	4385	4384	4384	4384	4383	4383	4382	4382	4381	4381	4382	4382	4383	4383	4384	4384	4384	4385	4385
4371	4371	4371	4371	4370	4370	4369	4369	4368	4368	4368	4368	4369	4369	4370	4370	4371	4371	4371	4371
4359	4359	4359	4359	4358	4358	4358	4357	4357	4357	4357	4357	4357	4358	4358	4358	4359	4359	4359	4359
4349	4349	4349	4348	4348	4348	4347	4347	4347	4346	4346	4347	4347	4347	4348	4348	4348	4349	4349	4349
4340	4340	4339	4339	4339	4339	4338	4338	4338	4337	4337	4338	4338	4338	4339	4339	4339	4339	4340	4340
4332	4332	4332	4331	4331	4331	4330	4330	4330	4330	4330	4330	4330	4330	4331	4331	4331	4332	4332	4332
4325	4325	4325	4324	4324	4324	4324	4324	4323	4323	4323	4323	4324	4324	4324	4324	4324	4325	4325	4325
4319	4319	4319	4318	4318	4318	4318	4318	4318	4317	4317	4318	4318	4318	4318	4318	4318	4319	4319	4319
4314	4314	4313	4313	4313	4313	4313	4313	4313	4312	4312	4313	4313	4313	4313	4313	4313	4313	4314	4314
4309	4309	4309	4309	4308	4308	4308	4308	4308	4308	4308	4308	4308	4308	4308	4308	4309	4309	4309	4309
4304	4304	4304	4304	4304	4304	4304	4304	4304	4304	4304	4304	4304	4304	4304	4304	4304	4304	4304	4304
4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300

TABLE C8

Temperature profile of surface temperature
simulation run 8 showing the
1 narrow groove configuration

4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514	4514
4504	4504	4504	4504	4504	4504	4504	4504	4504	4504	4504	4504	4504	4504	4504	4504	4504	4504	4504	4504
4495	4495	4495	4494	4494	4494	4494	4494	4494	4494	4494	4494	4494	4494	4494	4494	4494	4495	4495	4495
4485	4485	4485	4485	4485	4485	4485	4485	4485	4485	4485	4485	4485	4485	4485	4485	4485	4485	4485	4485
4477	4477	4477	4476	4476	4476	4476	4476	4476	4476	4476	4476	4476	4476	4476	4476	4476	4477	4477	4477
4469	4469	4469	4468	4468	4468	4468	4468	4468	4468	4468	4468	4468	4468	4468	4468	4468	4469	4469	4469
4461	4461	4461	4461	4461	4461	4461	4461	4461	4461	4461	4461	4461	4461	4461	4461	4461	4461	4461	4461
4455	4455	4454	4454	4454	4455	4455	4455	4456	4456	4456	4456	4455	4455	4455	4454	4454	4454	4455	4455
4449	4449	4448	4448	4448	4449	4449	4450	4453	4454	4454	4453	4450	4449	4449	4448	4448	4448	4449	4449
4443	4443	4443	4443	4443	4443	4443	4443	4444	4444	4444	4444	4443	4443	4443	4443	4443	4443	4443	4443
4439	4439	4439	4438	4438	4438	4438	4438	4438	4438	4438	4438	4438	4438	4438	4438	4438	4439	4439	4439
4436	4436	4436	4435	4435	4435	4435	4434	4434	4433	4433	4434	4434	4435	4435	4435	4435	4436	4436	4436
4434	4434	4434	4433	4433	4433	4433	4432	4431	4430	4430	4431	4432	4433	4433	4433	4433	4434	4434	4434
4434	4434	4433	4433	4433	4432	4432	4432	4428	4426	4426	4428	4432	4432	4432	4433	4433	4433	4434	4434
4416	4416	4416	4416	4415	4415	4414	4413	4412	4412	4412	4412	4413	4414	4415	4415	4416	4416	4416	4416
4440	4440	4440	4440	4399	4399	4398	4398	4397	4397	4397	4397	4398	4398	4399	4399	4400	4400	4400	4400
4386	4386	4386	4385	4385	4384	4384	4384	4383	4383	4383	4383	4384	4384	4384	4385	4385	4386	4386	4386
4373	4373	4373	4372	4372	4371	4371	4371	4370	4370	4370	4370	4371	4371	4371	4372	4372	4373	4373	4373
4361	4361	4361	4361	4360	4360	4360	4359	4359	4359	4359	4359	4359	4360	4360	4360	4361	4361	4361	4361
4351	4351	4350	4350	4350	4350	4349	4349	4349	4349	4349	4349	4349	4349	4350	4350	4350	4350	4351	4351
4341	4341	4341	4341	4341	4340	4340	4340	4340	4340	4340	4340	4340	4340	4340	4341	4341	4341	4341	4341
4333	4333	4333	4333	4332	4332	4332	4332	4332	4331	4331	4332	4332	4332	4332	4332	4333	4333	4333	4333
4325	4325	4325	4325	4325	4325	4325	4324	4324	4324	4324	4324	4324	4325	4325	4325	4325	4325	4325	4325
4319	4319	4318	4318	4318	4318	4318	4318	4318	4318	4318	4318	4318	4318	4318	4318	4318	4318	4319	4319
4312	4312	4312	4312	4312	4312	4312	4312	4312	4312	4312	4312	4312	4312	4312	4312	4312	4312	4312	4312
4306	4306	4306	4306	4306	4306	4306	4306	4306	4306	4306	4306	4306	4306	4306	4306	4306	4306	4306	4306
4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300	4300

TABLE C9

Temperature profile of surface temperature

simulation run 9 showing the 3 groove configuration

514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	513	513	514	514	514	514	514	514	514	513	513	514	514	514	514	514	514	514	513	513	514	514	514	514	514	514
514	514	514	514	514	513	512	512	513	514	514	514	514	514	513	512	512	513	514	514	514	514	514	513	512	512	513	514	514	514	514	514
514	514	514	514	514	512	511	511	512	514	514	514	514	514	512	511	511	512	514	514	514	514	514	512	511	511	512	514	514	514	514	514
514	514	514	514	514	511	509	509	511	514	514	514	514	514	511	509	509	511	514	514	514	514	514	511	509	509	511	514	514	514	514	514
514	514	514	514	514	507	505	505	507	514	514	514	514	514	507	505	505	507	514	514	514	514	514	507	505	505	507	514	514	514	514	514
471	471	471	471	471	469	469	469	469	471	471	471	471	471	469	469	469	469	471	471	471	471	471	469	469	469	469	471	471	471	472	471
428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	427	427	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428
386	386	386	386	385	385	385	385	385	385	386	386	386	385	385	385	385	385	385	386	386	386	385	385	385	385	385	385	386	386	386	386
343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343
300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300

TABLE C10

Temperature profile of surface temperature

simulation run 10 showing the

ideal temperature profile

514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514	514
471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471	471
428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428
386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386
343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343	343
300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300

C4 CONDUCTANCES OF SIMULATION RUN 16

Table C11 shows the conductances of simulation run 16. The conductances are in watts per degree Celsius.

Notation:

CA(I) - conductance in X-direction between nodal points 'I' and 'I + 1'

CU(I) - conductance in Y-direction between nodal points 'I' and 'I + M'

TABLE C11 - Conductances Of Surface Temperature Simulation Run 16

M= 32 N= 17

THE CONDUCTANCES IN WATTS PER DEGREE KELVIN ARE

CA(33)=	0.000000	CA(34)=	10.060708	CA(35)=	10.060708	CA(36)=	10.060708	CA(37)=	662.611765	CA(38)=	662.611765
CA(39)=	662.611765	CA(40)=	662.611765	CA(41)=	662.611765	CA(42)=	17.659754	CA(43)=	17.659754	CA(44)=	17.659754
CA(45)=	17.659754	CA(46)=	662.611765	CA(47)=	662.611765	CA(48)=	662.611765	CA(49)=	662.611765	CA(50)=	662.611765
CA(51)=	17.659754	CA(52)=	17.659754	CA(53)=	17.659754	CA(54)=	17.659754	CA(55)=	662.611765	CA(56)=	662.611765
CA(57)=	662.611765	CA(58)=	662.611765	CA(59)=	662.611765	CA(60)=	10.060708	CA(61)=	10.060708	CA(62)=	10.060708
CA(63)=	0.000000	CA(64)=	0.000000	CA(65)=	0.000000	CA(66)=	10.060708	CA(67)=	10.060708	CA(68)=	10.060708
CA(69)=	662.611765	CA(70)=	662.611765	CA(71)=	662.611765	CA(72)=	662.611765	CA(73)=	662.611765	CA(74)=	17.659754
CA(75)=	17.659754	CA(76)=	17.659754	CA(77)=	17.659754	CA(78)=	662.611765	CA(79)=	662.611765	CA(80)=	662.611765
CA(81)=	662.611765	CA(82)=	662.611765	CA(83)=	17.659754	CA(84)=	17.659754	CA(85)=	17.659754	CA(86)=	17.659754
CA(87)=	662.611765	CA(88)=	662.611765	CA(89)=	662.611765	CA(90)=	662.611765	CA(91)=	662.611765	CA(92)=	10.060708
CA(93)=	10.060708	CA(94)=	10.060708	CA(95)=	0.000000	CA(96)=	0.000000	CA(97)=	0.000000	CA(98)=	6.840000
CA(99)=	6.840000	CA(100)=	6.840000	CA(101)=	331.450000	CA(102)=	331.450000	CA(103)=	331.450000	CA(104)=	331.450000
CA(105)=	331.450000	CA(106)=	12.000000	CA(107)=	12.000000	CA(108)=	12.000000	CA(109)=	12.000000	CA(110)=	331.450000
CA(111)=	331.450000	CA(112)=	331.450000	CA(113)=	331.450000	CA(114)=	331.450000	CA(115)=	12.000000	CA(116)=	12.000000
CA(117)=	12.000000	CA(118)=	12.000000	CA(119)=	331.450000	CA(120)=	331.450000	CA(121)=	331.450000	CA(122)=	331.450000
CA(123)=	331.450000	CA(124)=	6.840000	CA(125)=	6.840000	CA(126)=	6.840000	CA(127)=	0.000000	CA(128)=	0.000000
CA(129)=	0.000000	CA(130)=	3.619726	CA(131)=	3.619726	CA(132)=	3.619726	CA(133)=	0.282000	CA(134)=	0.282000
CA(135)=	0.282000	CA(136)=	0.282000	CA(137)=	0.282000	CA(138)=	6.353774	CA(139)=	6.353774	CA(140)=	6.353774
CA(141)=	6.353774	CA(142)=	0.282000	CA(143)=	0.282000	CA(144)=	0.282000	CA(145)=	0.282000	CA(146)=	0.282000
CA(147)=	6.353774	CA(148)=	6.353774	CA(149)=	6.353774	CA(150)=	6.353774	CA(151)=	0.282000	CA(152)=	0.282000
CA(153)=	0.282000	CA(154)=	0.282000	CA(155)=	0.282000	CA(156)=	3.619726	CA(157)=	3.619726	CA(158)=	3.619726
CA(159)=	0.000000	CA(160)=	0.000000	CA(161)=	0.000000	CA(162)=	3.619726	CA(163)=	3.619726	CA(164)=	3.619726
CA(165)=	0.282000	CA(166)=	0.282000	CA(167)=	0.282000	CA(168)=	0.282000	CA(169)=	0.282000	CA(170)=	6.353774
CA(171)=	6.353774	CA(172)=	6.353774	CA(173)=	6.353774	CA(174)=	0.282000	CA(175)=	0.282000	CA(176)=	0.282000
CA(177)=	0.282000	CA(178)=	0.282000	CA(179)=	6.353774	CA(180)=	6.353774	CA(181)=	6.353774	CA(182)=	6.353774
CA(183)=	0.282000	CA(184)=	0.282000	CA(185)=	0.282000	CA(186)=	0.282000	CA(187)=	0.282000	CA(188)=	3.619726
CA(189)=	3.619726	CA(190)=	3.619726	CA(191)=	0.000000	CA(192)=	0.000000	CA(193)=	0.000000	CA(194)=	3.619726
CA(195)=	3.619726	CA(196)=	3.619726	CA(197)=	0.282000	CA(198)=	0.282000	CA(199)=	0.282000	CA(200)=	0.282000
CA(201)=	0.282000	CA(202)=	6.353774	CA(203)=	6.353774	CA(204)=	6.353774	CA(205)=	6.353774	CA(206)=	0.282000
CA(207)=	0.282000	CA(208)=	0.282000	CA(209)=	0.282000	CA(210)=	0.282000	CA(211)=	6.353774	CA(212)=	6.353774
CA(213)=	6.353774	CA(214)=	6.353774	CA(215)=	0.282000	CA(216)=	0.282000	CA(217)=	0.282000	CA(218)=	0.282000
CA(219)=	0.282000	CA(220)=	3.619726	CA(221)=	3.619726	CA(222)=	3.619726	CA(223)=	0.000000	CA(224)=	0.000000
CA(225)=	0.000000	CA(226)=	3.619726	CA(227)=	3.619726	CA(228)=	3.619726	CA(229)=	0.282000	CA(230)=	0.282000

TABLE C11 (continued)

CA(231)=	0.282000	CA(232)=	0.282000	CA(233)=	0.282000	CA(234)=	6.353774	CA(235)=	6.353774	CA(236)=	6.353774
CA(237)=	6.353774	CA(238)=	0.282000	CA(239)=	0.282000	CA(240)=	0.282000	CA(241)=	0.282000	CA(242)=	0.282000
CA(243)=	6.353774	CA(244)=	6.353774	CA(245)=	6.353774	CA(246)=	6.353774	CA(247)=	0.282000	CA(248)=	0.282000
CA(249)=	0.282000	CA(250)=	0.282000	CA(251)=	0.282000	CA(252)=	3.619726	CA(253)=	3.619726	CA(254)=	3.619726
CA(255)=	0.000000	CA(256)=	0.000000	CA(257)=	0.000000	CA(258)=	1.811000	CA(259)=	1.811000	CA(260)=	1.811000
CA(261)=	0.215200	CA(262)=	0.215200	CA(263)=	0.215200	CA(264)=	0.215200	CA(265)=	0.215200	CA(266)=	3.180000
CA(267)=	3.180000	CA(268)=	3.180000	CA(269)=	3.180000	CA(270)=	0.215200	CA(271)=	0.215200	CA(272)=	0.215200
CA(273)=	0.215200	CA(274)=	0.215200	CA(275)=	3.180000	CA(276)=	3.180000	CA(277)=	3.180000	CA(278)=	3.180000
CA(279)=	0.215200	CA(280)=	0.215200	CA(281)=	0.215200	CA(282)=	0.215200	CA(283)=	0.215200	CA(284)=	1.811000
CA(285)=	1.811000	CA(286)=	1.811000	CA(287)=	0.000000	CA(288)=	0.000000	CA(289)=	0.000000	CA(290)=	0.002253
CA(291)=	0.002253	CA(292)=	0.002253	CA(293)=	0.148405	CA(294)=	0.148405	CA(295)=	0.148405	CA(296)=	0.148405
CA(297)=	0.148405	CA(298)=	0.003955	CA(299)=	0.003955	CA(300)=	0.003955	CA(301)=	0.003955	CA(302)=	0.148405
CA(303)=	0.148405	CA(304)=	0.148405	CA(305)=	0.148405	CA(306)=	0.148405	CA(307)=	0.003955	CA(308)=	0.003955
CA(309)=	0.003955	CA(310)=	0.003955	CA(311)=	0.148405	CA(312)=	0.148405	CA(313)=	0.148405	CA(314)=	0.148405
CA(315)=	0.148405	CA(316)=	0.002253	CA(317)=	0.002253	CA(318)=	0.002253	CA(319)=	0.000000	CA(320)=	0.000000
CA(321)=	0.000000	CA(322)=	0.002253	CA(323)=	0.002253	CA(324)=	0.002253	CA(325)=	0.148405	CA(326)=	0.148405
CA(327)=	0.148405	CA(328)=	0.148405	CA(329)=	0.148405	CA(330)=	0.003955	CA(331)=	0.003955	CA(332)=	0.003955
CA(333)=	0.003955	CA(334)=	0.148405	CA(335)=	0.148405	CA(336)=	0.148405	CA(337)=	0.148405	CA(338)=	0.148405
CA(339)=	0.003955	CA(340)=	0.003955	CA(341)=	0.003955	CA(342)=	0.003955	CA(343)=	0.148405	CA(344)=	0.148405
CA(345)=	0.148405	CA(346)=	0.148405	CA(347)=	0.148405	CA(348)=	0.002253	CA(349)=	0.002253	CA(350)=	0.002253
CA(351)=	0.000000	CA(352)=	0.000000	CA(353)=	0.000000	CA(354)=	0.002253	CA(355)=	0.002253	CA(356)=	0.002253
CA(357)=	0.148405	CA(358)=	0.148405	CA(359)=	0.148405	CA(360)=	0.148405	CA(361)=	0.148405	CA(362)=	0.003955
CA(363)=	0.003955	CA(364)=	0.003955	CA(365)=	0.003955	CA(366)=	0.148405	CA(367)=	0.148405	CA(368)=	0.148405
CA(369)=	0.148405	CA(370)=	0.148405	CA(371)=	0.003955	CA(372)=	0.003955	CA(373)=	0.003955	CA(374)=	0.003955
CA(375)=	0.148405	CA(376)=	0.148405	CA(377)=	0.148405	CA(378)=	0.148405	CA(379)=	0.148405	CA(380)=	0.002253
CA(381)=	0.002253	CA(382)=	0.002253	CA(383)=	0.000000	CA(384)=	0.000000	CA(385)=	0.000000	CA(386)=	0.002253
CA(387)=	0.002253	CA(388)=	0.002253	CA(389)=	0.148405	CA(390)=	0.148405	CA(391)=	0.148405	CA(392)=	0.148405
CA(393)=	0.148405	CA(394)=	0.003955	CA(395)=	0.003955	CA(396)=	0.003955	CA(397)=	0.003955	CA(398)=	0.148405
CA(399)=	0.148405	CA(400)=	0.148405	CA(401)=	0.148405	CA(402)=	0.148405	CA(403)=	0.003955	CA(404)=	0.003955
CA(405)=	0.003955	CA(406)=	0.003955	CA(407)=	0.148405	CA(408)=	0.148405	CA(409)=	0.148405	CA(410)=	0.148405
CA(411)=	0.148405	CA(412)=	0.002253	CA(413)=	0.002253	CA(414)=	0.002253	CA(415)=	0.000000	CA(416)=	0.000000
CA(417)=	0.000000	CA(418)=	0.002253	CA(419)=	0.002253	CA(420)=	0.002253	CA(421)=	0.148405	CA(422)=	0.148405
CA(423)=	0.148405	CA(424)=	0.148405	CA(425)=	0.148405	CA(426)=	0.003955	CA(427)=	0.003955	CA(428)=	0.003955
CA(429)=	0.003955	CA(430)=	0.148405	CA(431)=	0.148405	CA(432)=	0.148405	CA(433)=	0.148405	CA(434)=	0.148405
CA(435)=	0.003955	CA(436)=	0.003955	CA(437)=	0.003955	CA(438)=	0.003955	CA(439)=	0.148405	CA(440)=	0.148405
CA(441)=	0.148405	CA(442)=	0.148405	CA(443)=	0.148405	CA(444)=	0.002253	CA(445)=	0.002253	CA(446)=	0.002253
CA(447)=	0.000000	CA(448)=	0.000000	CA(449)=	0.000000	CA(450)=	0.004500	CA(451)=	0.004500	CA(452)=	0.004500
CA(453)=	0.297000	CA(454)=	0.297000	CA(455)=	0.297000	CA(456)=	0.297000	CA(457)=	0.297000	CA(458)=	0.007912

TABLE C11 (continued)

CA(459)=	0.007918	CA(460)=	0.007918	CA(461)=	0.007918	CA(462)=	0.297000	CA(463)=	0.297000	CA(464)=	0.297000
CA(465)=	0.297000	CA(466)=	0.297000	CA(467)=	0.007918	CA(468)=	0.007918	CA(469)=	0.007918	CA(470)=	0.007918
CA(471)=	0.297000	CA(472)=	0.297000	CA(473)=	0.297000	CA(474)=	0.297000	CA(475)=	0.297000	CA(476)=	0.004500
CA(477)=	0.004500	CA(478)=	0.004500	CA(479)=	0.000000	CA(480)=	0.000000	CA(481)=	0.000000	CA(482)=	0.006765
CA(483)=	0.006765	CA(484)=	0.006765	CA(485)=	0.445567	CA(486)=	0.445567	CA(487)=	0.445567	CA(488)=	0.445567
CA(489)=	0.445567	CA(490)=	0.011875	CA(491)=	0.011875	CA(492)=	0.011875	CA(493)=	0.011875	CA(494)=	0.445567
CA(495)=	0.445567	CA(496)=	0.445567	CA(497)=	0.445567	CA(498)=	0.445567	CA(499)=	0.011875	CA(500)=	0.011875
CA(501)=	0.011875	CA(502)=	0.011875	CA(503)=	0.445567	CA(504)=	0.445567	CA(505)=	0.445567	CA(506)=	0.445567
CA(507)=	0.445567	CA(508)=	0.006765	CA(509)=	0.006765	CA(510)=	0.006765	CA(511)=	0.000000	CA(512)=	0.000000
CA(513)=	0.000000	CA(514)=	0.006765	CA(515)=	0.006765	CA(516)=	0.006765	CA(517)=	0.445567	CA(518)=	0.445567
CA(519)=	0.445567	CA(520)=	0.445567	CA(521)=	0.445567	CA(522)=	0.011875	CA(523)=	0.011875	CA(524)=	0.011875
CA(525)=	0.011875	CA(526)=	0.445567	CA(527)=	0.445567	CA(528)=	0.445567	CA(529)=	0.445567	CA(530)=	0.445567
CA(531)=	0.011875	CA(532)=	0.011875	CA(533)=	0.011875	CA(534)=	0.011875	CA(535)=	0.445567	CA(536)=	0.445567
CA(537)=	0.445567	CA(538)=	0.445567	CA(539)=	0.445567	CA(540)=	0.006765	CA(541)=	0.006765	CA(542)=	0.006765
CA(543)=	0.000000	CA(									

CU(1)=	0.000000	CU(2)=	56491.609977	CU(3)=	56491.609977	CU(4)=	56491.609977	CU(5)=	2867.470000	CU(6)=	85.773545
CU(7)=	85.773545	CU(8)=	85.773545	CU(9)=	85.773545	CU(10)=	1652.040000	CU(11)=	3218.309902	CU(12)=	3218.309902
CU(13)=	3218.309902	CU(14)=	1652.040000	CU(15)=	85.773545	CU(16)=	85.773545	CU(17)=	85.773545	CU(18)=	85.773545
CU(19)=	1652.040000	CU(20)=	3218.309902	CU(21)=	3218.309902	CU(22)=	3218.309902	CU(23)=	1652.040000	CU(24)=	85.773545
CU(25)=	85.773545	CU(26)=	85.773545	CU(27)=	85.773545	CU(28)=	2867.470000	CU(29)=	56491.609977	CU(30)=	56491.609977
CU(31)=	56491.609977	CU(32)=	0.000000	CU(33)=	0.000000	CU(34)=	56491.609977	CU(35)=	56491.609977	CU(36)=	56491.609977
CU(37)=	2867.470000	CU(38)=	85.773545	CU(39)=	85.773545	CU(40)=	85.773545	CU(41)=	85.773545	CU(42)=	1652.040000
CU(43)=	3218.309902	CU(44)=	3218.309902	CU(45)=	3218.309902	CU(46)=	1652.040000	CU(47)=	85.773545	CU(48)=	85.773545
CU(49)=	85.773545	CU(50)=	85.773545	CU(51)=	1652.040000	CU(52)=	3218.309902	CU(53)=	3218.309902	CU(54)=	3218.309902
CU(55)=	1652.040000	CU(56)=	85.773545	CU(57)=	85.773545	CU(58)=	85.773545	CU(59)=	85.773545	CU(60)=	2867.470000
CU(61)=	56491.609977	CU(62)=	56491.609977	CU(63)=	56491.609977	CU(64)=	0.000000	CU(65)=	0.000000	CU(66)=	56491.609977
CU(67)=	56491.609977	CU(68)=	56491.609977	CU(69)=	2867.470000	CU(70)=	85.773545	CU(71)=	85.773545	CU(72)=	85.773545
CU(73)=	85.773545	CU(74)=	1652.040000	CU(75)=	3218.309902	CU(76)=	3218.309902	CU(77)=	3218.309902	CU(78)=	1652.040000
CU(79)=	85.773545	CU(80)=	85.773545	CU(81)=	85.773545	CU(82)=	85.773545	CU(83)=	1652.040000	CU(84)=	3218.309902
CU(85)=	3218.309902	CU(86)=	3218.309902	CU(87)=	1652.040000	CU(88)=	85.773545	CU(89)=	85.773545	CU(90)=	85.773545
CU(91)=	85.773545	CU(92)=	2867.470000	CU(93)=	56491.609977	CU(94)=	56491.609977	CU(95)=	56491.609977	CU(96)=	0.000000
CU(97)=	0.000000	CU(98)=	15701.344538	CU(99)=	15701.344538	CU(100)=	15701.344538	CU(101)=	7850.810000	CU(102)=	0.282000
CU(103)=	0.282000	CU(104)=	0.282000	CU(105)=	0.282000	CU(106)=	4472.650000	CU(107)=	8945.008403	CU(108)=	8945.008403
CU(109)=	8945.008403	CU(110)=	4472.650000	CU(111)=	0.282000	CU(112)=	0.282000	CU(113)=	0.282000	CU(114)=	0.282000
CU(115)=	4472.650000	CU(116)=	8945.008403	CU(117)=	8945.008403	CU(118)=	8945.008403	CU(119)=	4472.650000	CU(120)=	0.282000
CU(121)=	0.282000	CU(122)=	0.282000	CU(123)=	0.282000	CU(124)=	7850.810000	CU(125)=	15701.344538	CU(126)=	15701.344538
CU(127)=	15701.344538	CU(128)=	0.000000	CU(129)=	0.000000	CU(130)=	15701.344538	CU(131)=	15701.344538	CU(132)=	15701.344538

TABLE C11 (continued)

CU(133)= 7850.810000	CU(134)= 0.282000	CU(135)= 0.282000	CU(136)= 0.282000	CU(137)= 0.282000	CU(138)= 4472.650000
CU(139)= 8945.008403	CU(140)= 8945.008403	CU(141)= 8945.008403	CU(142)= 4472.650000	CU(143)= 0.282000	CU(144)= 0.282000
CU(145)= 0.282000	CU(146)= 0.282000	CU(147)= 4472.650000	CU(148)= 8945.008403	CU(149)= 8945.008403	CU(150)= 8945.008403
CU(151)= 4472.650000	CU(152)= 0.282000	CU(153)= 0.282000	CU(154)= 0.282000	CU(155)= 0.282000	CU(156)= 7850.810000
CU(157)=15701.344538	CU(158)=15701.344538	CU(159)=15701.344538	CU(160)= 0.000000	CU(161)= 0.000000	CU(162)=15701.344538
CU(163)=15701.344538	CU(164)=15701.344538	CU(165)= 7850.810000	CU(166)= 0.282000	CU(167)= 0.282000	CU(168)= 0.282000
CU(169)= 0.282000	CU(170)= 4472.650000	CU(171)= 8945.008403	CU(172)= 8945.008403	CU(173)= 8945.008403	CU(174)= 4472.650000
CU(175)= 0.282000	CU(176)= 0.282000	CU(177)= 0.282000	CU(178)= 0.282000	CU(179)= 4472.650000	CU(180)= 8945.008403
CU(181)= 8945.008403	CU(182)= 8945.008403	CU(183)= 4472.650000	CU(184)= 0.282000	CU(185)= 0.282000	CU(186)= 0.282000
CU(187)= 0.282000	CU(188)= 7850.810000	CU(189)=15701.344538	CU(190)=15701.344538	CU(191)=15701.344538	CU(192)= 0.000000
CU(193)= 0.000000	CU(194)=15701.344538	CU(195)=15701.344538	CU(196)=15701.344538	CU(197)= 7850.810000	CU(198)= 0.282000
CU(199)= 0.282000	CU(200)= 0.282000	CU(201)= 0.282000	CU(202)= 4472.650000	CU(203)= 8945.008403	CU(204)= 8945.008403
CU(205)= 8945.008403	CU(206)= 4472.650000	CU(207)= 0.282000	CU(208)= 0.282000	CU(209)= 0.282000	CU(210)= 0.282000
CU(211)= 4472.650000	CU(212)= 8945.008403	CU(213)= 8945.008403	CU(214)= 8945.008403	CU(215)= 4472.650000	CU(216)= 0.282000
CU(217)= 0.282000	CU(218)= 0.282000	CU(219)= 0.282000	CU(220)= 7850.[illegible]00	CU(221)=15701.344538	CU(222)=15701.344538
CU(223)=15701.344538	CU(224)= 0.000000	CU(225)= 0.000000	CU(226)=15701.344538	CU(227)=15701.344538	CU(228)=15701.344538
CU(229)= 7850.810000	CU(230)= 0.282000	CU(231)= 0.282000	CU(232)= 0.282000	CU(233)= 0.282000	CU(234)= 4472.650000
CU(235)= 8945.008403	CU(236)= 8945.008403	CU(237)= 8945.008403	CU(238)= 4472.650000	CU(239)= 0.282000	CU(240)= 0.282000
CU(241)= 0.282000	CU(242)= 0.282000	CU(243)= 4472.650000	CU(244)= 8945.008403	CU(245)= 8945.008403	CU(246)= 8945.008403
CU(247)= 4472.650000	CU(248)= 0.282000	CU(249)= 0.282000	CU(250)= 0.282000	CU(251)= 0.282000	CU(252)= 7850.810000
CU(253)=15701.344538	CU(254)=15701.344538	CU(255)=15701.344538	CU(256)= 0.000000	CU(257)= 0.000000	CU(258)= 12.376950
CU(259)= 12.376950	CU(260)= 12.376950	CU(261)= 6.282000	CU(262)= 0.187924	CU(263)= 0.187924	CU(264)= 0.187924
CU(265)= 0.187924	CU(266)= 3.620000	CU(267)= 7.051111	CU(268)= 7.051111	CU(269)= 7.051111	CU(270)= 3.620000
CU(271)= 0.187924	CU(272)= 0.187924	CU(273)= 0.187924	CU(274)= 0.187924	CU(275)= 3.620000	CU(276)= 7.051111
CU(277)= 7.051111	CU(278)= 7.051111	CU(279)= 3.620000	CU(280)= 0.187924	CU(281)= 0.187924	CU(282)= 0.187924
CU(283)= 0.187924	CU(284)= 6.282000	CU(285)= 12.376950	CU(286)= 12.376950	CU(287)= 12.376950	CU(288)= 0.000000
CU(289)= 0.000000	CU(290)= 12.376950	CU(291)= 12.376950	CU(292)= 12.376950	CU(293)= 6.282000	CU(294)= 0.187924
CU(295)= 0.187924	CU(296)= 0.187924	CU(297)= 0.187924	CU(298)= 3.620000	CU(299)= 7.051111	CU(300)= 7.051111
CU(301)= 7.051111	CU(302)= 3.620000	CU(303)= 0.187924	CU(304)= 0.187924	CU(305)= 0.187924	CU(306)= 0.187924
CU(307)= 3.620000	CU(308)= 7.051111	CU(309)= 7.051111	CU(310)= 7.051111	CU(311)= 3.620000	CU(312)= 0.187924
CU(313)= 0.187924	CU(314)= 0.187924	CU(315)= 0.187924	CU(316)= 6.282000	CU(317)= 12.376950	CU(318)= 12.376950
CU(319)= 12.376950	CU(320)= 0.000000	CU(321)= 0.000000	CU(322)= 12.376950	CU(323)= 12.376950	CU(324)= 12.376950
CU(325)= 6.282000	CU(326)= 0.187924	CU(327)= 0.187924	CU(328)= 0.187924	CU(329)= 0.187924	CU(330)= 3.620000
CU(331)= 7.051111	CU(332)= 7.051111	CU(333)= 7.051111	CU(334)= 3.620000	CU(335)= 0.187924	CU(336)= 0.187924
CU(337)= 0.187924	CU(338)= 0.187924	CU(339)= 3.620000	CU(340)= 7.051111	CU(341)= 7.051111	CU(342)= 7.051111
CU(343)= 3.620000	CU(344)= 0.187924	CU(345)= 0.187924	CU(346)= 0.187924	CU(347)= 0.187924	CU(348)= 6.282000
CU(349)= 12.376950	CU(350)= 12.376950	CU(351)= 12.376950	CU(352)= 0.000000	CU(353)= 0.000000	CU(354)= 12.376950
CU(355)= 12.376950	CU(356)= 12.376950	CU(357)= 6.282000	CU(358)= 0.187924	CU(359)= 0.187924	CU(360)= 0.187924
CU(361)= 0.187924	CU(362)= 3.620000	CU(363)= 7.051111	CU(364)= 7.051111	CU(365)= 7.051111	CU(366)= 3.620000

TABLE C11 (continued)

CU(367)=	0.187924	CU(368)=	0.187924	CU(369)=	0.187924	CU(370)=	0.187924	CU(371)=	3.620000	CU(372)=	7.051111
CU(373)=	7.051111	CU(374)=	7.051111	CU(375)=	3.620000	CU(376)=	0.187924	CU(377)=	0.187924	CU(378)=	0.187924
CU(379)=	0.187924	CU(380)=	6.282000	CU(381)=	12.376950	CU(382)=	12.376950	CU(383)=	12.376950	CU(384)=	0.000000
CU(385)=	0.000000	CU(386)=	12.376950	CU(387)=	12.376950	CU(388)=	12.376950	CU(389)=	6.282000	CU(390)=	0.187924
CU(391)=	0.187924	CU(392)=	0.187924	CU(393)=	0.187924	CU(394)=	3.620000	CU(395)=	7.051111	CU(396)=	7.051111
CU(397)=	7.051111	CU(398)=	3.620000	CU(399)=	0.187924	CU(400)=	0.187924	CU(401)=	0.187924	CU(402)=	0.187924
CU(403)=	3.620000	CU(404)=	7.051111	CU(405)=	7.051111	CU(406)=	7.051111	CU(407)=	3.620000	CU(408)=	0.187924
CU(409)=	0.187924	CU(410)=	0.187924	CU(411)=	0.187924	CU(412)=	6.282000	CU(413)=	12.376950	CU(414)=	12.376950
CU(415)=	12.376950	CU(416)=	0.000000	CU(417)=	0.000000	CU(418)=	12.376950	CU(419)=	12.376950	CU(420)=	12.376950
CU(421)=	6.282000	CU(422)=	0.187924	CU(423)=	0.187924	CU(424)=	0.187924	CU(425)=	0.187924	CU(426)=	3.620000
CU(427)=	7.051111	CU(428)=	7.051111	CU(429)=	7.051111	CU(430)=	3.620000	CU(431)=	0.187924	CU(432)=	0.187924
CU(433)=	0.187924	CU(434)=	0.187924	CU(435)=	3.620000	CU(436)=	7.051111	CU(437)=	7.051111	CU(438)=	7.051111
CU(439)=	3.620000	CU(440)=	0.187924	CU(441)=	0.187924	CU(442)=	0.187924	CU(443)=	0.187924	CU(444)=	6.282000
CU(445)=	12.376950	CU(446)=	12.376950	CU(447)=	12.376950	CU(448)=	0.000000	CU(449)=	0.000000	CU(450)=	4.122402
CU(451)=	4.122402	CU(452)=	4.122402	CU(453)=	2.092000	CU(454)=	0.062592	CU(455)=	0.062592	CU(456)=	0.062592
CU(457)=	0.062592	CU(458)=	1.206000	CU(459)=	2.348520	CU(460)=	2.348520	CU(461)=	2.348520	CU(462)=	1.206000
CU(463)=	0.062592	CU(464)=	0.062592	CU(465)=	0.062592	CU(466)=	0.062592	CU(467)=	1.206000	CU(468)=	2.348520
CU(469)=	2.348520	CU(470)=	2.348520	CU(471)=	1.206000	CU(472)=	0.062592	CU(473)=	0.062592	CU(474)=	0.062592
CU(475)=	0.062592	CU(476)=	2.092000	CU(477)=	4.122402	CU(478)=	4.122402	CU(479)=	4.122402	CU(480)=	0.000000
CU(481)=	0.000000	CU(482)=	4.122402	CU(483)=	4.122402	CU(484)=	4.122402	CU(485)=	2.092000	CU(486)=	0.062592
CU(487)=	0.062592	CU(488)=	0.062592	CU(489)=	0.062592	CU(490)=	1.206000	CU(491)=	2.348520	CU(492)=	2.348520
CU(493)=	2.348520	CU(494)=	1.206000	CU(495)=	0.062592	CU(496)=	0.062592	CU(497)=	0.062592	CU(498)=	0.062592
CU(499)=	1.206000	CU(500)=	2.348520	CU(501)=	2.348520	CU(502)=	2.348520	CU(503)=	1.206000	CU(504)=	0.062592
CU(505)=	0.062592	CU(506)=	0.062592	CU(507)=	0.062592	CU(508)=	2.092000	CU(509)=	4.122402	CU(510)=	4.122402
CU(511)=	4.122402	CU(512)=	0.000000	CU(513)=	0.000000	CU(514)=	4.122402	CU(515)=	4.122402	CU(516)=	4.122402
CU(517)=	2.092000	CU(518)=	0.062592	CU(519)=	0.062592	CU(520)=	0.062592	CU(521)=	0.062592	CU(522)=	1.206000
CU(523)=	2.348520	CU(524)=	2.348520	CU(525)=	2.348520	CU(526)=	1.206000	CU(527)=	0.062592	CU(528)=	0.062592
CU(529)=	0.062592	CU(530)=	0.062592	CU(531)=	1.206000	CU(532)=	2.348520	CU(533)=	2.348520	CU(534)=	2.348520
CU(535)=	1.206000	CU(536)=	0.062592	CU(537)=	0.062592	CU(538)=	0.062592	CU(539)=	0.062592	CU(540)=	2.092000
CU(541)=	4.122402	CU(542)=	4.122402	CU(543)=	4.122402	CU(544)=	0.000000				

C5 HEAT FLOWS OF SIMULATION RUN 16

Table C12 shows the heat flows between nodal points in watts for the surface temperature simulation run number 16.

Notation:

QA(I) - heat flow in X-direction from nodal point 'I' towards nodal point 'I + 1'

QU(I) - heat flow in Y-direction from nodal point 'I' towards nodal point 'I + M'

TABLE C12 - Heat Flows

QA(33)=	0.0000	QU(2)=	1.7644
QA(34)=	0.0000	QU(3)=	1.7644
QA(35)=	0.0000	QU(4)=	1.7920
QA(36)=	0.0027	QU(5)=	0.8723
QA(37)=	-0.0016	QU(6)=	0.0259
QA(38)=	-0.0007	QU(7)=	0.0258
QA(39)=	0.0007	QU(8)=	0.0259
QA(40)=	0.0022	QU(9)=	0.0262
QA(41)=	0.0030	QU(10)=	0.5114
QA(42)=	0.0001	QU(11)=	1.0083
QA(43)=	-0.0000	QU(12)=	1.0077
QA(44)=	0.0000	QU(13)=	1.0087
QA(45)=	-0.0000	QU(14)=	0.5146
QA(46)=	-0.0024	QU(15)=	0.0264
QA(47)=	-0.0015	QU(16)=	0.0262
QA(48)=	-0.0000	QU(17)=	0.0262
QA(49)=	0.0015	QU(18)=	0.0264
QA(50)=	0.0024	QU(19)=	0.5146
QA(51)=	0.0000	QU(20)=	1.0090
QA(52)=	-0.0000	QU(21)=	1.0081
QA(53)=	0.0000	QU(22)=	1.0087
QA(54)=	-0.0001	QU(23)=	0.5115
QA(55)=	-0.0030	QU(24)=	0.0262
QA(56)=	-0.0022	QU(25)=	0.0259
QA(57)=	-0.0007	QU(26)=	0.0258
QA(58)=	0.0007	QU(27)=	0.0259
QA(59)=	0.0016	QU(28)=	0.8722
QA(60)=	-0.0027	QU(29)=	1.7920
QA(61)=	-0.0000	QU(30)=	1.7644
QA(62)=	-0.0000	QU(31)=	1.7644
QA(63)=	-0.0000	QU(32)=	0.0000
QA(65)=	0.0000	QU(34)=	1.7644
QA(66)=	0.0000	QU(35)=	1.7645
QA(67)=	0.0000	QU(36)=	1.7692
QA(68)=	0.0055	QU(37)=	0.8765
QA(69)=	-0.0111	QU(38)=	0.0250
QA(70)=	-0.0059	QU(39)=	0.0243
QA(71)=	0.0015	QU(40)=	0.0244
QA(72)=	0.0068	QU(41)=	0.0253
QA(73)=	0.0140	QU(42)=	0.5144
QA(74)=	0.0001	QU(43)=	1.0082
QA(75)=	-0.0000	QU(44)=	1.0075
QA(76)=	0.0000	QU(45)=	1.0086
QA(77)=	-0.0000	QU(46)=	0.5169
QA(78)=	-0.0127	QU(47)=	0.0255
QA(79)=	-0.0075	QU(48)=	0.0247
QA(80)=	-0.0000	QU(49)=	0.0247
QA(81)=	0.0074	QU(50)=	0.0255
QA(82)=	0.0127	QU(51)=	0.5168
QA(83)=	0.0000	QU(52)=	1.0089

TABLE C12 (continued)

QA(84)=	-0.0000	QU(53)=	1.0079
QA(85)=	0.0000	QU(54)=	1.0086
QA(86)=	-0.0001	QU(55)=	0.5144
QA(87)=	-0.0140	QU(56)=	0.0253
QA(88)=	-0.0089	QU(57)=	0.0244
QA(89)=	-0.0015	QU(58)=	0.0243
QA(90)=	0.0059	QU(59)=	0.0250
QA(91)=	0.0111	QU(60)=	0.0764
QA(92)=	-0.0055	QU(61)=	1.7092
QA(93)=	-0.0000	QU(62)=	1.7645
QA(94)=	-0.0000	QU(63)=	1.7644
QA(95)=	-0.0000	QU(64)=	0.0000
QA(97)=	-0.0000	QU(66)=	1.7644
QA(98)=	0.0000	QU(67)=	1.7645
QA(99)=	0.0000	QU(68)=	1.7638
QA(100)=	0.0057	QU(69)=	0.8930
QA(101)=	-0.0324	QU(70)=	0.0198
QA(102)=	-0.0138	QU(71)=	0.0170
QA(103)=	0.0012	QU(72)=	0.0171
QA(104)=	0.0163	QU(73)=	0.0201
QA(105)=	0.0352	QU(74)=	0.5202
QA(106)=	-0.0000	QU(75)=	1.0082
QA(107)=	-0.0000	QU(76)=	1.0073
QA(108)=	0.0000	QU(77)=	1.0085
QA(109)=	0.0001	QU(78)=	0.5294
QA(110)=	-0.0343	QU(79)=	0.0203
QA(111)=	-0.0153	QU(80)=	0.0173
QA(112)=	-0.0000	QU(81)=	0.0173
QA(113)=	0.0153	QU(82)=	0.0203
QA(114)=	0.0343	QU(83)=	0.5294
QA(115)=	-0.0001	QU(84)=	1.0087
QA(116)=	-0.0000	QU(85)=	1.0077
QA(117)=	0.0000	QU(86)=	1.0085
QA(118)=	0.0000	QU(87)=	0.5203
QA(119)=	-0.0352	QU(88)=	0.0201
QA(120)=	-0.0163	QU(89)=	0.0171
QA(121)=	-0.0012	QU(90)=	0.0170
QA(122)=	0.0138	QU(91)=	0.0198

TABLE C12 (continued)

QA(123)=	0.0324	QU(92)=	0.8929
QA(124)=	-0.0057	QU(93)=	1.7037
QA(125)=	-0.0000	QU(94)=	1.7645
QA(126)=	-0.0000	QU(95)=	1.7644
QA(127)=	0.0000	QU(96)=	0.0000
QA(129)=	-0.0000	QU(98)=	1.7644
QA(130)=	0.0000	QU(99)=	1.7645
QA(131)=	0.0000	QU(100)=	1.7781
QA(132)=	0.0030	QU(101)=	0.9307
QA(133)=	0.0012	QU(102)=	0.0012
QA(134)=	0.0007	QU(103)=	0.0019
QA(135)=	0.0000	QU(104)=	0.0019
QA(136)=	-0.0007	QU(105)=	0.0012
QA(137)=	-0.0012	QU(106)=	0.5632
QA(138)=	-0.0001	QU(107)=	1.0076
QA(139)=	-0.0000	QU(108)=	1.0067
QA(140)=	0.0000	QU(109)=	1.0078
QA(141)=	0.0001	QU(110)=	0.5635
QA(142)=	0.0012	QU(111)=	0.0012
QA(143)=	0.0007	QU(112)=	0.0020
QA(144)=	-0.0000	QU(113)=	0.0020
QA(145)=	-0.0007	QU(114)=	0.0012
QA(146)=	-0.0012	QU(115)=	0.5635
QA(147)=	-0.0001	QU(116)=	1.0080
QA(148)=	-0.0000	QU(117)=	1.0070
QA(149)=	0.0000	QU(118)=	1.0079
QA(150)=	0.0001	QU(119)=	0.5632
QA(151)=	0.0012	QU(120)=	0.0012
QA(152)=	0.0007	QU(121)=	0.0019
QA(153)=	-0.0000	QU(122)=	0.0019
QA(154)=	-0.0007	QU(123)=	0.0012
QA(155)=	-0.0012	QU(124)=	0.9307
QA(156)=	-0.0030	QU(125)=	1.7781
QA(157)=	-0.0000	QU(126)=	1.7645
QA(158)=	-0.0000	QU(127)=	1.7644
QA(159)=	0.0000	QU(128)=	0.0000
QA(161)=	-0.0000	QU(130)=	1.7644
QA(162)=	0.0000	QU(131)=	1.7645
QA(163)=	0.0000	QU(132)=	1.7751

TABLE C12 (continued)

QA(164)=	0.0030	QU(133)=	0.9323
QA(165)=	0.0028	QU(134)=	0.0017
QA(166)=	0.0017	QU(135)=	0.0027
QA(167)=	0.0000	QU(136)=	0.0027
QA(168)=	-0.0017	QU(137)=	0.0017
QA(169)=	-0.0028	QU(138)=	0.5619
QA(170)=	-0.0002	QU(139)=	1.0071
QA(171)=	-0.0000	QU(140)=	1.0062
QA(172)=	0.0000	QU(141)=	1.0072
QA(173)=	0.0002	QU(142)=	0.5623
QA(174)=	0.0028	QU(143)=	0.0017
QA(175)=	0.0017	QU(144)=	0.0027
QA(176)=	-0.0000	QU(145)=	0.0027
QA(177)=	-0.0017	QU(146)=	0.0017
QA(178)=	-0.0028	QU(147)=	0.5623
QA(179)=	-0.0002	QU(148)=	1.0074
QA(180)=	-0.0000	QU(149)=	1.0064
QA(181)=	0.0000	QU(150)=	1.0073
QA(182)=	0.0002	QU(151)=	0.5620
QA(183)=	0.0028	QU(152)=	0.0017
QA(184)=	0.0017	QU(153)=	0.0027
QA(185)=	-0.0000	QU(154)=	0.0027
QA(186)=	-0.0017	QU(155)=	0.0017
QA(187)=	-0.0028	QU(156)=	0.9323
QA(188)=	-0.0030	QU(157)=	1.7751
QA(189)=	-0.0000	QU(158)=	1.7645
QA(190)=	-0.0000	QU(159)=	1.7644
QA(191)=	0.0000	QU(160)=	0.0000
QA(193)=	-0.0000	QU(162)=	1.7644
QA(194)=	0.0000	QU(163)=	1.7644
QA(195)=	0.0000	QU(164)=	1.7721
QA(196)=	0.0031	QU(165)=	0.9323
QA(197)=	0.0056	QU(166)=	0.0028
QA(198)=	0.0032	QU(167)=	0.0043
QA(199)=	0.0000	QU(168)=	0.0043
QA(200)=	-0.0032	QU(169)=	0.0028
QA(201)=	-0.0056	QU(170)=	0.5591
QA(202)=	-0.0003	QU(171)=	1.0064

TABLE C12 (continued)

QA(203)=	-0.0000	QU(172)=	1.0057
QA(204)=	0.0000	QU(173)=	1.0065
QA(205)=	0.0003	QU(174)=	0.5594
QA(206)=	0.0056	QU(175)=	0.0028
QA(207)=	0.0032	QU(176)=	0.0043
QA(208)=	-0.0000	QU(177)=	0.0043
QA(209)=	-0.0032	QU(178)=	0.0028
QA(210)=	-0.0056	QU(179)=	0.5594
QA(211)=	-0.0003	QU(180)=	1.0066
QA(212)=	-0.0000	QU(181)=	1.0058
QA(213)=	0.0000	QU(182)=	1.0065
QA(214)=	0.0003	QU(183)=	0.5592
QA(215)=	0.0056	QU(184)=	0.0028
QA(216)=	0.0032	QU(185)=	0.0043
QA(217)=	-0.0000	QU(186)=	0.0043
QA(218)=	-0.0032	QU(187)=	0.0028
QA(219)=	-0.0056	QU(188)=	0.9322
QA(220)=	-0.0031	QU(189)=	1.7721
QA(221)=	-0.0000	QU(190)=	1.7644
QA(222)=	-0.0000	QU(191)=	1.7644
QA(223)=	0.0000	QU(192)=	0.0000
QA(225)=	-0.0000	QU(194)=	1.7644
QA(226)=	0.0000	QU(195)=	1.7644
QA(227)=	0.0000	QU(196)=	1.7691
QA(228)=	0.0031	QU(197)=	0.9295
QA(229)=	0.0108	QU(198)=	0.0052
QA(230)=	0.0055	QU(199)=	0.0075
QA(231)=	0.0000	QU(200)=	0.0075
QA(232)=	-0.0055	QU(201)=	0.0052
QA(233)=	-0.0108	QU(202)=	0.5536
QA(234)=	-0.0003	QU(203)=	1.0057
QA(235)=	-0.0000	QU(204)=	1.0051
QA(236)=	0.0000	QU(205)=	1.0058
QA(237)=	0.0003	QU(206)=	0.5539
QA(238)=	0.0108	QU(207)=	0.0052
QA(239)=	0.0055	QU(208)=	0.0075
QA(240)=	-0.0000	QU(209)=	0.0075
QA(241)=	-0.0055	QU(210)=	0.0052
QA(242)=	-0.0108	QU(211)=	0.5539

TABLE C12 (continued)

QA(243)=	-0.0003	QU(212)=	1.0058
QA(244)=	-0.0000	QU(213)=	1.0052
QA(245)=	0.0000	QU(214)=	1.0057
QA(246)=	0.0003	QU(215)=	0.5536
QA(247)=	0.0108	QU(216)=	0.0052
QA(248)=	0.0055	QU(217)=	0.0075
QA(249)=	-0.0000	QU(218)=	0.0075
QA(250)=	-0.0055	QU(219)=	0.0052
QA(251)=	-0.0108	QU(220)=	0.9295
QA(252)=	-0.0031	QU(221)=	1.7690
QA(253)=	-0.0000	QU(222)=	1.7644
QA(254)=	-0.0000	QU(223)=	1.7644
QA(255)=	0.0000	QU(224)=	0.0000
QA(257)=	-0.0000	QU(226)=	1.7644
QA(258)=	0.0000	QU(227)=	1.7644
QA(259)=	0.0000	QU(228)=	1.7660
QA(260)=	0.0015	QU(229)=	0.9215
QA(261)=	0.0162	QU(230)=	0.0105
QA(262)=	0.0061	QU(231)=	0.0130
QA(263)=	0.0000	QU(232)=	0.0130
QA(264)=	-0.0061	QU(233)=	0.0105
QA(265)=	-0.0163	QU(234)=	0.5430
QA(266)=	-0.0002	QU(235)=	1.0049
QA(267)=	-0.0000	QU(236)=	1.0046
QA(268)=	0.0000	QU(237)=	1.0049
QA(269)=	0.0002	QU(238)=	0.5432
QA(270)=	0.0163	QU(239)=	0.0105
QA(271)=	0.0061	QU(240)=	0.0131
QA(272)=	-0.0000	QU(241)=	0.0131
QA(273)=	-0.0061	QU(242)=	0.0105
QA(274)=	-0.0163	QU(243)=	0.5432
QA(275)=	-0.0002	QU(244)=	1.0049
QA(276)=	-0.0000	QU(245)=	1.0046
QA(277)=	0.0000	QU(246)=	1.0049
QA(278)=	0.0002	QU(247)=	0.5430
QA(279)=	0.0163	QU(248)=	0.0105
QA(280)=	0.0061	QU(249)=	0.0130
QA(281)=	-0.0000	QU(250)=	0.0130

TABLE C12 (continued)

QA(282)=	-0.0061	QU(251)=	0.0105
QA(283)=	-0.0162	QU(252)=	0.9215
QA(284)=	-0.0015	QU(253)=	1.7660
QA(285)=	-0.0000	QU(254)=	1.7644
QA(286)=	-0.0000	QU(255)=	1.7644
QA(287)=	0.0000	QU(256)=	0.0000
QA(289)=	-0.0000	QU(258)=	1.7644
QA(290)=	0.0000	QU(259)=	1.7644
QA(291)=	0.0000	QU(260)=	1.7644
QA(292)=	0.0000	QU(261)=	0.9069
QA(293)=	0.0060	QU(262)=	0.0206
QA(294)=	0.0031	QU(263)=	0.0191
QA(295)=	0.0000	QU(264)=	0.0191
QA(296)=	-0.0030	QU(265)=	0.0207
QA(297)=	-0.0059	QU(266)=	0.5270
QA(298)=	-0.0000	QU(267)=	1.0049
QA(299)=	-0.0000	QU(268)=	1.0048
QA(300)=	0.0000	QU(269)=	1.0049
QA(301)=	0.0000	QU(270)=	0.5272
QA(302)=	0.0060	QU(271)=	0.0207
QA(303)=	0.0030	QU(272)=	0.0192
QA(304)=	-0.0000	QU(273)=	0.0192
QA(305)=	-0.0030	QU(274)=	0.0207
QA(306)=	-0.0060	QU(275)=	0.5272
QA(307)=	-0.0000	QU(276)=	1.0049
QA(308)=	-0.0000	QU(277)=	1.0048
QA(309)=	0.0000	QU(278)=	1.0049
QA(310)=	0.0000	QU(279)=	0.5270
QA(311)=	0.0059	QU(280)=	0.0207
QA(312)=	0.0030	QU(281)=	0.0191
QA(313)=	-0.0000	QU(282)=	0.0191
QA(314)=	-0.0031	QU(283)=	0.0206
QA(315)=	-0.0060	QU(284)=	0.9069
QA(316)=	-0.0000	QU(285)=	1.7644
QA(317)=	-0.0000	QU(286)=	1.7644
QA(318)=	-0.0000	QU(287)=	1.7644
QA(319)=	0.0000	QU(288)=	0.0000
QA(321)=	-0.0000	QU(290)=	1.7644

TABLE C12 (continued)

QA(323)=	0.0000	QU(292)=	1.7644
QA(324)=	0.0000	QU(293)=	0.9009
QA(325)=	0.0034	QU(294)=	0.0236
QA(326)=	0.0019	QU(295)=	0.0222
QA(327)=	0.0000	QU(296)=	0.0222
QA(328)=	-0.0018	QU(297)=	0.0236
QA(329)=	-0.0032	QU(298)=	0.5211
QA(330)=	-0.0000	QU(299)=	1.0049
QA(331)=	-0.0000	QU(300)=	1.0048
QA(332)=	0.0000	QU(301)=	1.0049
QA(333)=	0.0000	QU(302)=	0.5213
QA(334)=	0.0033	QU(303)=	0.0237
QA(335)=	0.0019	QU(304)=	0.0222
QA(336)=	-0.0000	QU(305)=	0.0222
QA(337)=	-0.0019	QU(306)=	0.0237
QA(338)=	-0.0033	QU(307)=	0.5213
QA(339)=	-0.0000	QU(308)=	1.0049
QA(340)=	-0.0000	QU(309)=	1.0048
QA(341)=	0.0000	QU(310)=	1.0049
QA(342)=	0.0000	QU(311)=	0.5211
QA(343)=	0.0032	QU(312)=	0.0236
QA(344)=	0.0018	QU(313)=	0.0222
QA(345)=	-0.0000	QU(314)=	0.0222
QA(346)=	-0.0019	QU(315)=	0.0236
QA(347)=	-0.0034	QU(316)=	0.9009
QA(348)=	-0.0000	QU(317)=	1.7644
QA(349)=	-0.0000	QU(318)=	1.7644
QA(350)=	-0.0000	QU(319)=	1.7644
QA(351)=	0.0000	QU(320)=	0.0000
QA(353)=	-0.0000	QU(322)=	1.7644
QA(354)=	0.0000	QU(323)=	1.7644
QA(355)=	0.0000	QU(324)=	1.7644
QA(356)=	0.0000	QU(325)=	0.8975
QA(357)=	0.0019	QU(326)=	0.0250
QA(358)=	0.0012	QU(327)=	0.0240
QA(359)=	0.0001	QU(328)=	0.0241
QA(360)=	-0.0011	QU(329)=	0.0250
QA(361)=	-0.0018	QU(330)=	0.5178

TABLE C12 (continued)

QA(362)=	-0.0000	QU(331)=	1.0049
QA(363)=	-0.0000	QU(332)=	1.0048
QA(364)=	0.0000	QU(333)=	1.0049
QA(365)=	0.0000	QU(334)=	0.5180
QA(366)=	0.0018	QU(335)=	0.0251
QA(367)=	0.0011	QU(336)=	0.0241
QA(368)=	-0.0000	QU(337)=	0.0241
QA(369)=	-0.0011	QU(338)=	0.0251
QA(370)=	-0.0018	QU(339)=	0.5180
QA(371)=	-0.0000	QU(340)=	1.0049
QA(372)=	-0.0000	QU(341)=	1.0048
QA(373)=	0.0000	QU(342)=	1.0049
QA(374)=	0.0000	QU(343)=	0.5178
QA(375)=	0.0018	QU(344)=	0.0250
QA(376)=	0.0011	QU(345)=	0.0241
QA(377)=	-0.0001	QU(346)=	0.0240
QA(378)=	-0.0012	QU(347)=	0.0250
QA(379)=	-0.0019	QU(348)=	0.8975
QA(380)=	-0.0000	QU(349)=	1.7644
QA(381)=	-0.0000	QU(350)=	1.7644
QA(382)=	-0.0000	QU(351)=	1.7644
QA(383)=	0.0000	QU(352)=	0.0000
QA(385)=	-0.0000	QU(354)=	1.7644
QA(386)=	0.0000	QU(355)=	1.7644
QA(387)=	0.0000	QU(356)=	1.7644
QA(388)=	0.0000	QU(357)=	0.8956
QA(389)=	0.0011	QU(358)=	0.0258
QA(390)=	0.0007	QU(359)=	0.0252
QA(391)=	0.0001	QU(360)=	0.0252
QA(392)=	-0.0006	QU(361)=	0.0258
QA(393)=	-0.0010	QU(362)=	0.5161
QA(394)=	-0.0000	QU(363)=	1.0048
QA(395)=	-0.0000	QU(364)=	1.0048
QA(396)=	0.0000	QU(365)=	1.0048
QA(397)=	0.0000	QU(366)=	0.5162
QA(398)=	0.0010	QU(367)=	0.0258
QA(399)=	0.0006	QU(368)=	0.0252
QA(400)=	-0.0000	QU(369)=	0.0252

TABLE C12 (continued)

QA(402)=	-0.0010	QU(371)=	0.5162
QA(403)=	-0.0000	QU(372)=	1.0048
QA(404)=	-0.0000	QU(373)=	1.0048
QA(405)=	0.0000	QU(374)=	1.0048
QA(406)=	0.0000	QU(375)=	0.5161
QA(407)=	0.0010	QU(376)=	0.0258
QA(408)=	0.0006	QU(377)=	0.0252
QA(409)=	-0.0001	QU(378)=	0.0252
QA(410)=	-0.0007	QU(379)=	0.0258
QA(411)=	-0.0011	QU(380)=	0.0956
QA(412)=	-0.0000	QU(381)=	1.7644
QA(413)=	-0.0000	QU(382)=	1.7644
QA(414)=	-0.0000	QU(383)=	1.7644
QA(415)=	0.0000	QU(384)=	0.0000
QA(417)=	0.0000	QU(386)=	1.7644
QA(418)=	0.0000	QU(387)=	1.7644
QA(419)=	0.0000	QU(388)=	1.7644
QA(420)=	0.0000	QU(389)=	0.0945
QA(421)=	0.0006	QU(390)=	0.0262
QA(422)=	0.0004	QU(391)=	0.0258
QA(423)=	0.0001	QU(392)=	0.0258
QA(424)=	-0.0003	QU(393)=	0.0262
QA(425)=	-0.0005	QU(394)=	0.5151
QA(426)=	-0.0000	QU(395)=	1.0048
QA(427)=	-0.0000	QU(396)=	1.0048
QA(428)=	0.0000	QU(397)=	1.0048
QA(429)=	0.0000	QU(398)=	0.5152
QA(430)=	0.0006	QU(399)=	0.0262
QA(431)=	0.0004	QU(400)=	0.0258
QA(432)=	-0.0000	QU(401)=	0.0258
QA(433)=	-0.0004	QU(402)=	0.0262
QA(434)=	-0.0006	QU(403)=	0.5152
QA(435)=	-0.0000	QU(404)=	1.0048
QA(436)=	-0.0000	QU(405)=	1.0048
QA(437)=	0.0000	QU(406)=	1.0048
QA(438)=	0.0000	QU(407)=	0.5151
QA(439)=	0.0005	QU(408)=	0.0262
QA(440)=	0.0003	QU(409)=	0.0258

TABLE C12 (continued)

QA(441)=	-0.0001	QU(410)=	0.0250
QA(442)=	-0.0004	QU(411)=	0.0262
QA(443)=	-0.0006	QU(412)=	0.0945
QA(444)=	-0.0000	QU(413)=	1.7644
QA(445)=	-0.0000	QU(414)=	1.7644
QA(446)=	-0.0000	QU(415)=	1.7644
QA(447)=	-0.0000	QU(416)=	0.0000
QA(449)=	0.0000	QU(418)=	1.7644
QA(450)=	0.0000	QU(419)=	1.7644
QA(451)=	0.0000	QU(420)=	1.7644
QA(452)=	0.0000	QU(421)=	0.8939
QA(453)=	0.0007	QU(422)=	0.0264
QA(454)=	0.0005	QU(423)=	0.0262
QA(455)=	0.0001	QU(424)=	0.0262
QA(456)=	-0.0003	QU(425)=	0.0264
QA(457)=	-0.0005	QU(426)=	0.5146
QA(458)=	-0.0000	QU(427)=	1.0048
QA(459)=	-0.0000	QU(428)=	1.0048
QA(460)=	0.0000	QU(429)=	1.0048
QA(461)=	0.0000	QU(430)=	0.5147
QA(462)=	0.0006	QU(431)=	0.0264
QA(463)=	0.0004	QU(432)=	0.0262
QA(464)=	-0.0000	QU(433)=	0.0262
QA(465)=	-0.0004	QU(434)=	0.0264
QA(466)=	-0.0006	QU(435)=	0.5147
QA(467)=	-0.0000	QU(436)=	1.0048
QA(468)=	-0.0000	QU(437)=	1.0048
QA(469)=	0.0000	QU(438)=	1.0048
QA(470)=	0.0000	QU(439)=	0.5146
QA(471)=	0.0005	QU(440)=	0.0264
QA(472)=	0.0003	QU(441)=	0.0262
QA(473)=	-0.0001	QU(442)=	0.0262
QA(474)=	-0.0005	QU(443)=	0.0264
QA(475)=	-0.0007	QU(444)=	0.8939
QA(476)=	-0.0000	QU(445)=	1.7644
QA(477)=	-0.0000	QU(446)=	1.7644
QA(478)=	-0.0000	QU(447)=	1.7644
QA(479)=	-0.0000	QU(448)=	0.0000
QA(481)=	0.0000	QU(450)=	1.7644

TABLE C12 (continued)

QA(482)=	0.0000	QU(451)=	1.7644
QA(483)=	0.0000	QU(452)=	1.7644
QA(484)=	0.0000	QU(453)=	0.8932
QA(485)=	0.0003	QU(454)=	0.0266
QA(486)=	0.0002	QU(455)=	0.0265
QA(487)=	0.0001	QU(456)=	0.0265
QA(488)=	-0.0000	QU(457)=	0.0266
QA(489)=	-0.0001	QU(458)=	0.5141
QA(490)=	-0.0000	QU(459)=	1.0048
QA(491)=	-0.0000	QU(460)=	1.0048
QA(492)=	0.0000	QU(461)=	1.0048
QA(493)=	0.0000	QU(462)=	0.5141
QA(494)=	0.0002	QU(463)=	0.0266
QA(495)=	0.0001	QU(464)=	0.0265
QA(496)=	-0.0000	QU(465)=	0.0265
QA(497)=	-0.0001	QU(466)=	0.0266
QA(498)=	-0.0002	QU(467)=	0.5141
QA(499)=	-0.0000	QU(468)=	1.0048
QA(500)=	-0.0000	QU(469)=	1.0048
QA(501)=	0.0000	QU(470)=	1.0048
QA(502)=	0.0000	QU(471)=	0.5141
QA(503)=	0.0001	QU(472)=	0.0266
QA(504)=	0.0000	QU(473)=	0.0265
QA(505)=	-0.0001	QU(474)=	0.0265
QA(506)=	-0.0002	QU(475)=	0.0266
QA(507)=	-0.0003	QU(476)=	0.8932
QA(508)=	-0.0000	QU(477)=	1.7644
QA(509)=	-0.0000	QU(478)=	1.7644
QA(510)=	-0.0000	QU(479)=	1.7644
QA(511)=	-0.0000	QU(480)=	0.0000
QA(513)=	0.0000	QU(482)=	1.7644
QA(514)=	0.0000	QU(483)=	1.7644
QA(515)=	0.0000	QU(484)=	1.7644
QA(516)=	0.0000	QU(485)=	0.8929
QA(517)=	0.0001	QU(486)=	0.0267
QA(518)=	0.0001	QU(487)=	0.0267
QA(519)=	0.0000	QU(488)=	0.0267
QA(520)=	0.0000	QU(489)=	0.0267

TABLE C12 (continued)

QA(521)=	0.0000
QA(522)=	-0.0000
QA(523)=	-0.0000
QA(524)=	0.0000
QA(525)=	0.0000
QA(526)=	0.0000
QA(527)=	0.0000
QA(528)=	-0.0000
QA(529)=	-0.0000
QA(530)=	-0.0000
QA(531)=	-0.0000
QA(532)=	-0.0000
QA(533)=	0.0000
QA(534)=	0.0000
QA(535)=	-0.0000
QA(536)=	-0.0000
QA(537)=	-0.0000
QA(538)=	-0.0001
QA(539)=	-0.0001
QA(540)=	-0.0000
QA(541)=	-0.0000
QA(542)=	-0.0000
QA(543)=	-0.0000
QU(514)=	1.7644
QU(515)=	1.7644
QU(516)=	1.7644
QU(517)=	0.8929
QU(518)=	0.0267
QU(519)=	0.0267
QU(520)=	0.0267
QU(521)=	0.0267
QU(522)=	0.5141
QU(523)=	1.0047
QU(524)=	1.0048
QU(525)=	1.0047
QU(526)=	0.5139
QU(527)=	0.0267
QU(528)=	0.0267
QU(529)=	0.0267
QU(490)=	0.5141
QU(491)=	1.0047
QU(492)=	1.0048
QU(493)=	1.0047
QU(494)=	0.5140
QU(495)=	0.0267
QU(496)=	0.0266
QU(497)=	0.0266
QU(498)=	0.0267
QU(499)=	0.5140
QU(500)=	1.0047
QU(501)=	1.0048
QU(502)=	1.0047
QU(503)=	0.5141
QU(504)=	0.0267
QU(505)=	0.0267
QU(506)=	0.0267
QU(507)=	0.0267
QU(508)=	0.8929
QU(509)=	1.7644
QU(510)=	1.7644
QU(511)=	1.7644
QU(512)=	0.0000
QU(530)=	0.0267
QU(531)=	0.5139
QU(532)=	1.0047
QU(533)=	1.0048
QU(534)=	1.0047
QU(535)=	0.5141
QU(536)=	0.0267
QU(537)=	0.0267
QU(538)=	0.0267
QU(539)=	0.0267
QU(540)=	0.8929
QU(541)=	1.7644
QU(542)=	1.7644
QU(543)=	1.7644

C6 COMPUTER LISTING

Table C13 shows the basic computer listing of the program used in the surface temperature simulations.

Subroutine conduc was altered for each simulation run - due to the different grid sizes and hence conductances used. For the interested readers, the conductances were evaluated using two different algorithms: (a) as outlined at the start of the program, that is, reading in numerous data cards and/or (b) reading in a few data cards and equating the equal conductances as shown in subroutine conduc.

TABLE C13

Computer Listing Of Surface Temperature Simulation Program

```
 B6700/B7700    F O R T R A N    C O M P I L A T I O N    M A R K    2.7.300

      DIMENSION CA(576),CU(576),OA(576),OU(576),T(576),RES(576)
      DIMENSION TT(576)
C
C
C     RELAXATION OF A RECTANGULAR GRID OF POINTS IN TWO
C     DIMENSIONS CONSIDERING ONLY CONVECTIVE AND CONDUCTIVE HEAT
C     TRANSFER
C
C     IF CONVECTIVE HEAT TRANSFER IS BEING CONSIDERED, THEN
C     H=CONVECTIVE HEAT TRANSFER COEFFICIENT
C     A=SURFACE AREA OF HEAT TRANSFER
C     D=1
C
C     IF CONDUCTIVE HEAT TRANSFER IS BEING CONSIDERED, THEN
C     H=K,THE THERMAL CONDUCTIVITY
C     A=CROSS-SECTIONAL AREA OF HEAT TRANSFER
C     D=LENGTH OVER WHICH HEAT IS BEING TRANSFERED
C
C     CONDUCTANCE=C=H*A/D IN WATTS PER DEGREE KELVIN
C
C     ARRANGING THE DATA CARDS
C     THE FIRST CARD HAS THE VALUES OF M AND N ON IT.
C
C     THE NEXT SET OF CARDS HAS THE CONDUCTANCE VALUES
C     AT THE END OF THE CONDUCTANCE CARDS, PUT IN A DUMMY CARD
C     IN THE SAME FORMAT AS THE OTHER CONDUCTANCE CARDS
C
C     THE GUESSED TEMPERATURES CONSTITUTE THE NEXT SET OF
C     DATA CARDS PARTICULAR ATTENTION TO BOUNDARY CONDITIONS MUST BE
C     PAID
C
C
C     CONSIDER FOR EXAMPLE THE NETWORK SHOWN BELOW
C     WITH N=4 AND M=6
C
C     T19*********T20*********T21*********T22*********T23*********T24
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C     T13*********T14*********T15*********T16*********T17*********T18
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C     T7**********T8**********T9**********T10*********T11*********T12
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C      *           *           *           *           *           *
C     T1**********T2**********T3**********T4**********T5**********T6
C
C     THE CONDUCTANCES ARE READ IN,IN THE FOLLOWING ORDER
C     CA(7),CU(2),CA(8),CU(3),CA(9),ETC,ETC,CA(10),CU(5),AND CA(11)
C     THE NEXT LINE BEING CA(13),CU(8),CA(14),CU(9)ETC.
C     HAVING READ IN CA(24),THEN READ IN, THE UPPER BOUNDARY CONDITIONS
```

TABLE C13 (continued)

```
C        NAMELY,CU(20),CU(21),CU(22),CU(23)
C
C        THE GUESSED TEMPERATURES BEING READ IN ACCORDING
C        TO THE FORMAT OF STATEMENT 41, FROM T1 UP TO T30
C        NR=NUMBER OF ROW BEING COMPUTED
C        K=TEMPERATURE COUNTER
C
C        M=NUMBER OF GRID POINTS IN THE X DIRECTION
C
C        N=NUMBER OF GRID POINTS IN THE Y DIRECTION
C
         READ(5,19)M,N
      19 FORMAT(2I3)
         MN1=(N+1)*M
         WRITE(6,42)M,N
      42 FORMAT(//,11X,'M=',I3,10X,'N=',I3)
C        EVALUATION OF CONDUCTANCES
C        CA=CONDUCTANCE ACROSS THE GRID IN X-DIRECTION
C        CU=CONDUCTANCE UP IN THE GRID IN Y-DIRECTION
         WRITE(6,34)
      34 FORMAT(///,11X,'THE CONDUCTANCES IN WATTS PER DEGREE KELVIN ARE')
         CALL CONDUC(CA,CU)
         WRITE(6,48)
      48 FORMAT(///,11X,'THE GUESSED TEMPERATURES FOR THE POINTS ARE')
         READ(5,41)(T(I),I=1,MN1)
         WRITE(6,47)(I,T(I),I=1,MN1)
      47 FORMAT(///,(1X,8(2X,'T(',I3,'): ',F6.2)))
C        EVALUATING THE TEMP. AND GRID POINTS
         CALL RELAX(T,CA,CU,RES,M,N)
      41 FORMAT(16F5.2)
C        EVALUATING THE HEAT FLOW BETWEEN GRID POINTS
         WRITE(6,36)
      36 FORMAT(///,11X,'THE HEAT FLUX PROFILE IS!)
         CALL HEATFL(T,CA,CU,QA,QU,M,N)
         CONTINUE
         STOP
         END
```

TABLE C13 (continued)

```
      SUBROUTINE CONDUC(CA,CU)
      DIMENSION CA(576),CU(576)
C     SETTING BOUNDARY CONDITIONS FOR ZERO HEAT FLUX
      READ(5,11)H,A,D
   11 FORMAT(3F12.7)
      CA(33)=H*A/D
      CA(63)=CA(33)
      DO 12I=33,461,32
      CA(I+32)=CA(I)
   12 CA(I+62)=CA(I)
C
C     EVALUATING BOUNDARY CONDITIONS BETWEEN VARIOUS REGIONS
C
C     READING CONDUCTANCES BTWN REGIONS A+B AND ALSO B+C
      READ(5,13)HAB,AAB,DAB,HBC,ABC,DBC
   13 FORMAT(6F12.7)
      CU(5)=HAB*AAB/DAB
      CU(28)=CU(5)
      CU(10)=HBC*ABC/DBC
      CU(14)=CU(10)
      CU(19)=CU(10)
      CU(23)=CU(10)
      DO 14 I=5,37,32
      CU(I+32)=CU(I)
   14 CU(I+55)=CU(I)
      DO 15I=10,42,32
      CU(I+32)=CU(I)
      CU(I+36)=CU(I)
      CU(I+41)=CU(I)
   15 CU(I+45)=CU(I)
C     READING CONDUCTANCES BTWN REGIONS A+I AND ALSO B+E
      READ(5,13)HAI,AAI,DAI,HBE,ABE,DBE
      CA(98)=HAI*AAI/DAI
      CA(126)=CA(98)
      CA(101)=HBE*ABE/DBE
      CA(114)=CA(101)
      CA(123)=CA(101)
      DO 16 I=98,99,1
      CA(I+1)=CA(I)
   16 CA(I+26)=CA(I)
      DO 17I=101,104
      CA(I+1)=CA(I)
      CA(I+9)=CA(I)
   17 CA(I+10)=CA(I)
C     READING CONDUCTANCES BTWN REGIONS C+D AND ALSO I+E
      READ(5,13)HCD,ACD,DCD,HIE,AIE,DIE
      CA(106)=HCD*ACD/DCD
      CA(118)=CA(106)
      DO 18I=106,108,1
      CA(I+1)=CA(I)
   18 CA(I+9)=CA(I)
      CU(101)=HIE*AIE/DIE
      CU(252)=CU(101)
      DO 19I=101,197,32
      CU(I+32)=CU(I)
   19 CU(I+23)=CU(I)
C     READING CONDUCTANCES BTWN REGIONS E+D AND ALSO I+J
      READ(5,13)HED,AED,DED,HIJ,AIJ,DIJ
      CU(106)=HED*AED/DED
      CU(238)=CU(106)
      CU(243)=CU(106)
      CU(247)=CU(106)
      DO 20I=106,202,32
      CU(I+32)=CU(I)
      CU(I+4)=CU(I)
      CU(I+9)=CU(I)
   20 CU(I+13)=CU(I)
      CA(258)=HIJ*AIJ/DIJ
      CA(286)=CA(258)
      DO 21I=258,259,1
      CA(I+1)=CA(I)
   21 CA(I+26)=CA(I)
C     READING CONDUCTANCES BTWN REGIONS E+K AND ALSO D+L
      READ(5,13)HEK,AEK,DEK,HDL,ADL,DDL
      CA(261)=HEK*AEK/DEK
      CA(274)=CA(261)
```

TABLE C13 (continued)

```
      CA(283)=CA(261)
      DO 22I=261,264,1
      CA(I+1)=CA(I)
      CA(I+9)=CA(I)
   22 CA(I+18)=CA(I)
      CA(266)=HDL*ADL/DDL
      CA(276)=CA(266)
      DO 23I=266,268,1
      CA(I+1)=CA(I)
   23 CA(I+9)=CA(I)
C     READING CONDUCTANCES BTWN J+K AND K+L
      READ(5,13)HJK,AJK,DJK,HKL,AKL,DKL
      CU(261)=HJK*AJK/DJK
      CU(444)=CU(261)
      DO 24I=261,389,32
      CU(I+32)=CU(I)
   24 CU(I+23)=CU(I)
      CU(266)=HKL*AKL/DKL
      CU(430)=CU(266)
      CU(435)=CU(266)
      CU(439)=CU(266)
      DO 25I=266,394,32
      CU(I+32)=CU(I)
      CU(I+4)=CU(I)
      CU(I+9)=CU(I)
   25 CU(I+13)=CU(I)
C     READING CONDUCTANCES BTWN REGIONS J+F AND ALSO K+G
      READ(5,13)HJF,AJF,DJF,HKG,AKG,DKG
      CA(450)=HJF*AJF/DJF
      CA(478)=CA(450)
      DO 26I=450,451,1
      CA(I+1)=CA(I)
   26 CA(I+26)=CA(I)
      CA(453)=HKG*AKG/DKG
      CA(466)=CA(453)
      CA(475)=CA(453)
      DO 27I=453,456,1
      CA(I+1)=CA(I)
      CA(I+9)=CA(I)
   27 CA(I+18)=CA(I)
C     READING CONDUCTANCES BTWN REGIONS L+H AND ALSO F+G
      READ(5,13)HLH,ALH,DLH,HFG,AFG,DFG
      CA(458)=HLH*ALH/DLH
      CA(470)=CA(458)
      DO 28I=458,460,1
      CA(I+1)=CA(I)
   28 CA(I+9)=CA(I)
      CU(453)=HFG*AFG/DFG
      CU(540)=CU(453)
      DO 29I=453,485,32
      CU(I+32)=CU(I)
   29 CU(I+23)=CU(I)
C     READING CONDUCTANCES BTWN REGIONS G+H
      READ(5,30)HGH,AGH,DGH
   30 FORMAT(3F12.7)
      CU(458)=HGH*AGH/DGH
      CU(526)=CU(458)
      CU(531)=CU(458)
      CU(535)=CU(458)
      DO 31I=458,490,32
      CU(I+32)=CU(I)
      CU(I+4)=CU(I)
      CU(I+9)=CU(I)
   31 CU(I+13)=CU(I)
C
C     NOW THAT ALL THE BOUNDARY CONDITIONS HAVE BEEN READ IN,
C     THE HORIZONTAL AND VERTICAL CONDUCTANCES FOR EACH REGION
C     ARE EVALUATED AS SHOWN BELOW
C
C     READING CONDUCTANCES OF REGION A-CA AND CU
      READ(5,13)HAA,AAA,DAA,HAU,AAU,DAU
      CA(34)=HAA*AAA/DAA
      CA(62)=CA(34)
      CA(68)=CA(34)
      CA(94)=CA(34)
      CU(2)=HAU*AAU/DAU
      DO 32I=34,35,1
```

TABLE C13 (continued)

```
      CA(I+1)=CA(I)
      CA(I+32)=CA(I)
      CA(I+26)=CA(I)
   32 CA(I+58)=CA(I)
      CU(36)=CU(2)
      CU(68)=CU(2)
      CU(31)=CU(2)
      CU(63)=CU(2)
      CU(95)=CU(2)
      DO 33I=2,3,1
      CU(I+1)=CU(I)
      CU(I+32)=CU(I)
      CU(I+64)=CU(I)
      CU(I+27)=CU(I)
      CU(I+59)=CU(I)
   33 CU(I+91)=CU(I)
C     READING CONDUCTANCES OF REGIONB=CA AND CU
      READ(5,13)HBA,ABA,DBA,HBU,ABU,DBU
      CA(37)=HBA*ABA/DBA
      CA(73)=CA(37)
      CA(50)=CA(37)
      CA(62)=CA(37)
      CA(59)=CA(37)
      CA(91)=CA(37)
      DO 34I=37,40,1
      CA(I+1)=CA(I)
      CA(I+32)=CA(I)
      CA(I+9)=CA(I)
      CA(I+41)=CA(I)
      CA(I+18)=CA(I)
   34 CA(I+50)=CA(I)
      CU(6)=HBU*ABU/DBU
      CU(41)=CU(6)
      CU(73)=CU(6)
      CU(18)=CU(6)
      CU(50)=CU(6)
      CU(82)=CU(6)
      CU(27)=CU(6)
      CU(59)=CU(6)
      CU(91)=CU(6)
      DO 35I=6,8,1
      CU(I+1)=CU(I)
      CU(I+32)=CU(I)
      CU(I+64)=CU(I)
      CU(I+9)=CU(I)
      CU(I+41)=CU(I)
      CU(I+73)=CU(I)
      CU(I+18)=CU(I)
      CU(I+50)=CU(I)
   35 CU(I+82)=CU(I)
C     READING CONDUCTANCES OF REGION C=CA AND CU
      READ(5,13)HCA,ACA,DCA,HCU,ACU,DCU
      CA(42)=HCA*ACA/DCA
      CA(77)=CA(42)
      CA(86)=CA(42)
      CA(54)=CA(42)
      DO 36I=42,44,1
      CA(I+1)=CA(I)
      CA(I+32)=CA(I)
      CA(I+9)=CA(I)
   36 CA(I+41)=CA(I)
      CU(11)=HCU*ACU/DCU
      CU(45)=CU(11)
      CU(77)=CU(11)
      CU(22)=CU(11)
      CU(54)=CU(11)
      CU(86)=CU(11)
      DO 37I=11,12,1
      CU(I+1)=CU(I)
      CU(I+32)=CU(I)
      CU(I+64)=CU(I)
      CU(I+9)=CU(I)
      CU(I+41)=CU(I)
   37 CU(I+73)=CU(I)
C     READING CONDUCTANCES OF REGION I=CA AND CU
      READ(5,13)HIA,AIA,DIA,HIU,AIU,DIU
      CA(130)=HIA*AIA/DIA
```

TABLE C13 (continued)

```
      CU(98)=HIU*AIU/DIU
      DO 38 I=130,131,1
      CA(I+1)=CA(I)
      CA(I+32)=CA(I)
      CA(I+64)=CA(I)
      CA(I+96)=CA(I)
      CA(I+26)=CA(I)
      CA(I+58)=CA(I)
      CA(I+90)=CA(I)
38    CA(I+122)=CA(I)
      CA(164)=CA(130)
      CA(196)=CA(130)
      CA(228)=CA(130)
      CA(158)=CA(130)
      CA(190)=CA(130)
      CA(222)=CA(130)
      CA(254)=CA(130)
      DO 39 I=98,99,1
      CU(I+1)=CU(I)
      CU(I+32)=CU(I)
      CU(I+64)=CU(I)
      CU(I+96)=CU(I)
      CU(I+128)=CU(I)
      CU(I+27)=CU(I)
      CU(I+59)=CU(I)
      CU(I+91)=CU(I)
      CU(I+123)=CU(I)
39    CU(I+155)=CU(I)
      CU(132)=CU(98)
      CU(164)=CU(98)
      CU(196)=CU(98)
      CU(228)=CU(98)
      CU(127)=CU(98)
      CU(159)=CU(98)
      CU(191)=CU(98)
      CU(223)=CU(98)
      CU(255)=CU(98)
C     READING CONDUCTANCES OF REGIONE' CA AND CU
      READ(5,13)HEA,AEA,DEA,HEU,AEU,DEU
      CA(133)=HEA*AEA/DEA
      CA(169)=CA(133)
      CA(201)=CA(133)
      CA(233)=CA(133)
      CA(146)=CA(133)
      CA(178)=CA(133)
      CA(210)=CA(133)
      CA(242)=CA(133)
      CA(155)=CA(133)
      CA(187)=CA(133)
      CA(219)=CA(133)
      CA(251)=CA(133)
      DO 40 I=133,136,1
      CA(I+1)=CA(I)
      CA(I+32)=CA(I)
      CA(I+64)=CA(I)
      CA(I+96)=CA(I)
      CA(I+9)=CA(I)
      CA(I+41)=CA(I)
      CA(I+73)=CA(I)
      CA(I+105)=CA(I)
      CA(I+18)=CA(I)
      CA(I+50)=CA(I)
      CA(I+82)=CA(I)
40    CA(I+114)=CA(I)
      CU(102)=HEU*AEU/DEU
      CU(137)=CU(102)
      CU(169)=CU(102)
      CU(201)=CU(102)
      CU(233)=CU(102)
      CU(114)=CU(102)
      CU(146)=CU(102)
      CU(178)=CU(102)
      CU(210)=CU(102)
      CU(242)=CU(102)
      CU(123)=CU(102)
      CU(155)=CU(102)
      CU(187)=CU(102)
```

TABLE C13 (continued)

```
      CU(219)=CU(102)
      CU(251)=CU(102)
      DO 41I=102,104,1
      CU(I+1)=CU(I)
      CU(I+32)=CU(I)
      CU(I+64)=CU(I)
      CU(I+96)=CU(I)
      CU(I+128)=CU(I)
      CU(I+9)=CU(I)
      CU(I+41)=CU(I)
      CU(I+73)=CU(I)
      CU(I+105)=CU(I)
      CU(I+137)=CU(I)
      CU(I+18)=CU(I)
      CU(I+50)=CU(I)
      CU(I+82)=CU(I)
      CU(I+114)=CU(I)
   41 CU(I+146)=CU(I)
C     READING CONDUCTANCES OF REGIOND=CA AND CU
      READ(5,13)HDA,ADA,DDA,HDU,ADU,DDU
      CA(138)=HDA*ADA/DDA
      CA(173)=CA(138)
      CA(205)=CA(138)
      CA(237)=CA(138)
      CA(150)=CA(138)
      CA(182)=CA(138)
      CA(214)=CA(138)
      CA(246)=CA(138)
      DO 42I=138,140,1
      CA(I+1)=CA(I)
      CA(I+32)=CA(I)
      CA(I+64)=CA(I)
      CA(I+96)=CA(I)
      CA(I+9)=CA(I)
      CA(I+41)=CA(I)
      CA(I+73)=CA(I)
   42 CA(I+105)=CA(I)
      CU(107)=HDU*ADU/DDU
      CU(141)=CU(107)
      CU(173)=CU(107)
      CU(205)=CU(107)
      CU(237)=CU(107)
      CU(118)=CU(107)
      CU(150)=CU(107)
      CU(182)=CU(107)
      CU(214)=CU(107)
      CU(246)=CU(107)
      DO 43I=107,108,1
      CU(I+1)=CU(I)
      CU(I+32)=CU(I)
      CU(I+64)=CU(I)
      CU(I+96)=CU(I)
      CU(I+128)=CU(I)
      CU(I+9)=CU(I)
      CU(I+41)=CU(I)
      CU(I+73)=CU(I)
      CU(I+105)=CU(I)
   43 CU(I+137)=CU(I)
C     READING CONDUCTANCES OF REGION J=CA AND CU
      READ(5,13)HJA,AJA,DJA,HJU,AJU,DJU
      CA(290)=HJA*AJA/DJA
      CA(310)=CA(290)
      DO 44I=310,414,32
   44 CA(I+32)=CA(I)
      DO 45I=290,291,1
      CA(I+1)=CA(I)
      CA(I+32)=CA(I)
      CA(I+64)=CA(I)
      CA(I+96)=CA(I)
      CA(I+128)=CA(I)
      CA(I+26)=CA(I)
      CA(I+58)=CA(I)
      CA(I+90)=CA(I)
      CA(I+122)=CA(I)
   45 CA(I+154)=CA(I)
      DO 46I=292,368,32
   46 CA(I+32)=CA(I)
```

TABLE C13 (continued)

```
      CU(258)=HJU*AJU/DJU
      CU(267)=CU(258)
      DO 47I=258,259,1
      CU(I+1)=CU(I)
      CU(I+32)=CU(I)
      CU(I+64)=CU(I)
      CU(I+96)=CU(I)
      CU(I+128)=CU(I)
      CU(I+160)=CU(I)
      CU(I+27)=CU(I)
      CU(I+59)=CU(I)
      CU(I+91)=CU(I)
      CU(I+123)=CU(I)
      CU(I+155)=CU(I)
   47 CU(I+187)=CU(I)
      DO 48I=260,388,32
      CU(I+32)=CU(I)
   48 CU(I+59)=CU(I)
C     READING CONDUCTANCES OF REGION K-CA AND CU
      READ(5,13)HKA,AKA,DKA,HKU,AKU,DKU
      CA(293)=HKA*AKA/DKA
      CA(306)=CA(293)
      CA(315)=CA(293)
      DO 49I=293,296,1
      CA(I+1)=CA(I)
      CA(I+32)=CA(I)
      CA(I+64)=CA(I)
      CA(I+96)=CA(I)
      CA(I+128)=CA(I)
      CA(I+9)=CA(I)
      CA(I+41)=CA(I)
      CA(I+73)=CA(I)
      CA(I+105)=CA(I)
      CA(I+137)=CA(I)
      CA(I+18)=CA(I)
      CA(I+50)=CA(I)
      CA(I+82)=CA(I)
      CA(I+114)=CA(I)
   49 CA(I+146)=CA(I)
      DO 50I=297,393,32
      CA(I+32)=CA(I)
      CA(I+41)=CA(I)
   50 CA(I+50)=CA(I)
      CU(262)=HKU*AKU/DKU
      CU(274)=CU(262)
      CU(283)=CU(262)
      DO 51I=262,264,1
      CU(I+1)=CU(I)
      CU(I+32)=CU(I)
      CU(I+64)=CU(I)
      CU(I+96)=CU(I)
      CU(I+128)=CU(I)
      CU(I+160)=CU(I)
      CU(I+9)=CU(I)
      CU(I+41)=CU(I)
      CU(I+73)=CU(I)
      CU(I+105)=CU(I)
      CU(I+137)=CU(I)
      CU(I+169)=CU(I)
      CU(I+18)=CU(I)
      CU(I+50)=CU(I)
      CU(I+82)=CU(I)
      CU(I+114)=CU(I)
      CU(I+146)=CU(I)
   51 CU(I+178)=CU(I)
      DO 52I=265,393,32
      CU(I+32)=CU(I)
      CU(I+41)=CU(I)
   52 CU(I+50)=CU(I)
C     READING CONDUCTANCES OF REGION L-CA AND CU.
      READ(5,13)HLA,ALA,DLA,HLU,ALU,DLU
      CA(298)=HLA*ALA/DLA
      CA(310)=CA(298)
      DO 53I=298,300,1
      CA(I+1)=CA(I)
      CA(I+32)=CA(I)
      CA(I+64)=CA(I)
```

TABLE C13 (continued)

```
      CA(I+96)=CA(I)
      CA(I+128)=CA(I)
      CA(I+9)=CA(I)
      CA(I+41)=CA(I)
      CA(I+73)=CA(I)
      CA(I+105)=CA(I)
   53 CA(I+137)=CA(I)
      DO 54 I=301,397,32
      CA(I+32)=CA(I)
   54 CA(I+41)=CA(I)
      CU(267)=HLU*ALU/DLU
      CU(278)=CU(267)
      DO 55I=267,268,1
      CU(I+1)=CU(I)
      CU(I+32)=CU(I)
      CU(I+64)=CU(I)
      CU(I+96)=CU(I)
      CU(I+128)=CU(I)
      CU(I+160)=CU(I)
      CU(I+9)=CU(I)
      CU(I+41)=CU(I)
      CU(I+73)=CU(I)
      CU(I+105)=CU(I)
      CU(I+137)=CU(I)
   55 CU(I+169)=CU(I)
      DO 56I=269,397,32
      CU(I+32)=CU(I)
   56 CU(I+41)=CU(I)
C     READING CONDUCTANCES OF REGION F-CA AND CU
      READ(5,13)HFA,AFA,DFA,HFU,AFU,DFU
      CA(482)=HFA*AFA/DFA
      CA(516)=CA(482)
      CA(510)=CA(482)
      CA(542)=CA(482)
      DO 57I=482,483,1
      CA(I+1)=CA(I)
      CA(I+32)=CA(I)
      CA(I+26)=CA(I)
   57 CA(I+58)=CA(I)
      CU(450)=HFU*AFU/DFU
      CU(484)=CU(450)
      CU(516)=CU(450)
      CU(479)=CU(450)
      CU(511)=CU(450)
      CU(543)=CU(450)
      DO 58I=450,451,1
      CU(I+1)=CU(I)
      CU(I+32)=CU(I)
      CU(I+64)=CU(I)
      CU(I+27)=CU(I)
      CU(I+59)=CU(I)
   58 CU(I+91)=CU(I)
C     READING CONDUCTANCES OF REGION G-CA AND CU
      READ(5,13)HGA,AGA,DGA,HGU,AGU,DGU
      CA(485)=HGA*AGA/DGA
      CA(521)=CA(485)
      CA(498)=CA(485)
      CA(530)=CA(485)
      CA(507)=CA(485)
      CA(539)=CA(485)
      DO 59I=485,488,1
      CA(I+1)=CA(I)
      CA(I+32)=CA(I)
      CA(I+9)=CA(I)
      CA(I+41)=CA(I)
      CA(I+18)=CA(I)
   59 CA(I+50)=CA(I)
      CU(454)=HGU*AGU/DGU
      CU(530)=CU(454)
      CU(539)=CU(454)
      DO 60I=454,456,1
      CU(I+1)=CU(I)
      CU(I+32)=CU(I)
      CU(I+64)=CU(I)
      CU(I+9)=CU(I)
      CU(I+41)=CU(I)
      CU(I+73)=CU(I)
```

TABLE C13 (continued)

```
      CU(I+18)=CU(I)
      CU(I+50)=CU(I)
   60 CU(I+82)=CU(I)
      DO 61I=457,489,32
      CU(I+32)=CU(I)
      CU(I+9)=CU(I)
   61 CU(I+18)=CU(I)
C     READING CONDUCTANCES OF REGION H-CA AND CU
      READ(5,13)HHA,AHA,DHA,HHU,AHJ,DHU
      CA(490)=HHA*AHA/DHA
      CA(525)=CA(490)
      CA(502)=CA(490)
      CA(534)=CA(490)
      DO 62I=490,492,1
      CA(I+1)=CA(I)
      CA(I+32)=CA(I)
      CA(I+9)=CA(I)
   62 CA(I+41)=CA(I)
      CU(459)=HHU*AHU/DHU
      CU(534)=CU(459)
      DO 63I=459,460,1
      CU(I+1)=CU(I)
      CU(I+32)=CU(I)
      CU(I+64)=CU(I)
      CU(I+9)=CU(I)
      CU(I+41)=CU(I)
   63 CU(I+73)=CU(I)
      DO 64I=461,493,32
      CU(I+32)=CU(I)
   64 CU(I+9)=CU(I)
C     WRITING THE CONDUCTANCES-FIRSTLY CA AND THEN CU
      WRITE(6,65)(I,CA(I),I=33,543)
 65   FORMAT(///,(1X,/,1X,6('CA(',I3,')=',F12.6,2X)))
      WRITE(6,66)(I,CU(I),I=1,544)
 66   FORMAT(///,(1X,/,1X,6('CU(',I3,')=',F12.6,2X)))
      RETURN
      END
```

TABLE C13 (continued)

```
      SUBROUTINE RELAX(T,CA,CU,RES,M,N)
      DIMENSION T(576),CA(576),CU(576),RES(576)
      DIMENSION TT(576)
      W=1.26
C     W IS THE RELAXATION FACTOR
      KI=1
C     KI IS THE COUNTER OF THE NUMBER OF RESIDUAL ITERATIONS
      M1=M-1
      M2=M+1
      M3=2*M
      LL=1
      L=40
C     LL AND L ARE COUNTERS FOR WRITING THE TEMP PROFILE
C     EVERY 3 ITERATIONS
      TOL=0.005
   24 NR=1
      TOLM=1.E-02
      K=2
      MR=(NR*M)-1
   21 CONTINUE
      IF(K.GT.MR)GO TO 20
      KM1=K+M1
      KM=K+M
      KM2=K+M2
      KM3=K+M3
      DEN=(CA(KM1)*T(KM1))+(CA(KM)*T(KM2))+(CU(K)*T(K))+(CU(KM)*T(KM3))
      DENUM=DEN/(CA(KM1)+CA(KM)+CU(K)+CU(KM))
      RES(KM)=DENUM-T(KM)
      T(KM)=T(KM)+(W*RES(KM))
      K=K+1
      GO TO 21
   20 K=K+2
      NR=NR+1
      MR=MR+M
      IF(NR.EQ.N)GO TO 22
      GO TO 21
   22 CONTINUE
C     THE FIRST ESTIMATE OF TEMPS HAS BEEN OBTAINED
C     RESIDUALS ITERATING STARTS HERE
      NR=1
      K=2
      KM=K+M
      MR=(NR*M)-1
   28 CONTINUE
      IF(K.GT.MR)GO TO 26
      IF(ABS(RES(KM)).GT.TOLM)GO TO 25
      K=K+1
      KM=K+M
      GO TO 28
   25 TOLM=RES(KM)
      K=K+1
      KM=K+M
      GO TO 28
   26 K=K+2
      NR=NR+1
      MR=MR+M
      IF(NR.EQ.N)GO TO 27
      GO TO 28
   27 IF(ABS(TOLM).LE.TOL)GO TO 29
      IF(KI.GT.400)GO TO 29
      IF(KI.EQ.L)GO TO 52
      KI=KI+1
      GO TO 24
   52 WRITE(6,46)KI
   46 FORMAT(///,11X,'THE NUMBER OF RESIDUAL ITERATIONS FOR THE TEMPERAT
     1URE PROFILE SHOWN BELOW=',I3)
      DO 71 J=1,545,32
      NW=J+15
 71   WRITE(6,70)(T(I),I=J,NW,1)
 70   FORMAT(1X,16(F6.3,2X))
   54 FORMAT(///,(1X,32(I3,1X)))
      KI=KI+1
      LL=LL+1
      L=40*LL
      GO TO 24
   29 CONTINUE
```

TABLE C13 (continued)

```
      WRITE(6,72)
72    FORMAT(///,1X,'THE TEMPERATURE PROFILE FOR THE WHOLE NETWORK IS=')
      WRITE(6,46)KI
      WRITE(6,75)
75    FORMAT(///,1X,'THE TEMP PROFILE FOR L.H.S. OF NETWORK=')
      DO 73 J=1,543,32
      NW=J+15
73    WRITE(6,70)(T(I),I=J,NW,1)
      WRITE(6,76)
76    FORMAT(///,1X,'THE TEMP. PROFILE FOR R.H.S. OF NETWORK =')
      DO 74 J=17,561,32
      NW2=J+15
74    WRITE(6,70)(T(I),I=J,NW2,1)
      WRITE(6,46)KI
      MN1=(N+1)*M
      SF=100.
      DO 65 I=1,MN1
      TT(I)=T(I)*SF
65    TT(I)=TT(I)-4000.
      WRITE(6,54)(TT(I),I=1,MN1,1)
      RETURN
      END
```

TABLE C13 (continued)

```
      SUBROUTINE HEATFL(T,CA,CU,QA,QU,M,N)
      DIMENSION T(576),CA(576),CU(576),QA(576),QU(576)
      NR=1
      K=2
      M1=M-1
      MR=(NR*M)-1
   33 CONTINUE
      IF(K.GT.MR)GO TO 31
      KM=K+M
      KM1=K+M1
      QA(KM1)=CA(KM1)*(T(KM1)-T(KM))
      QU(K)=CU(K)*(T(K)-T(KM))
      WRITE(6,50)KM1,QA(KM1),K,QU(K)
   50 FORMAT(/,20X,'QA(',I3,')=',F12.4,9X,'QU(',I3,')=',F12.4)
      K=K+1
      GO TO 33
   31 CONTINUE
      KM=K+M
      KM1=K+M1
      QA(KM1)=CA(KM1)*(T(KM1)-T(KM))
      WRITE(6,50)KM1,QA(KM1),K,QU(K)
      K=K+2
      NR=NR+1
      MR=MR+M
      IF(NR.EQ.N)GO TO 32
      GO TO 33
   32 CONTINUE
      IF(K.GT.MR)GO TO 37
      KM=K+M
      QU(K)=CU(K)*(T(K)-T(KM))
      WRITE(6,51)K,QU(K)
   51 FORMAT(/,20X,'QU(',I3,')=',F12.4)
      K=K+1
      GO TO 32
   37 CONTINUE
      RETURN
      END
```

APPENDIX D

CALIBRATION OF THERMOCOUPLES

D1 WORKING STANDARD

The platinum resistance thermometer was calibrated by the National Physical Laboratory, Teddington, England. The results of the calibration were given in tabular form; resistance ratio (W) versus temperature.

$W = \frac{R(T)}{R(273.15^{\circ}K)}$ over the temperature range from $273^{\circ}K$ to $90^{\circ}K$ and $W = \frac{R(t)}{R(0^{\circ}C)}$ over the temperature range from $0^{\circ}C$ to $500^{\circ}C$, $T = t+273.15$ and R is the resistance of the platinum resistor.

The heating effect of a measuring current of 1 milliampere when the thermometer was immersed in unstirred water was 0.00013 ohms.

The value of $R(0^{\circ}C)$ after the stability test was 25.4899 ohms; the final value being 25.4893 ohms.

Table D1 gives the resistance ratio (W) of the platinum resistance thermometer in the temperature range used in the thermocouple calibrations.

The standard resistor used in the thermocouple calibrations was a 25.5 ohms H. Tinsley and Co. class S standard resistor number 188.092. The National Physical Laboratory measured its resistance at $20^{\circ}C$: 25.4999 ± 0.0001 ohms.

D2 THE COMPARISON BRIDGE

The Rosemount Engineering Company precision comparison bridge model VLF 51A is specifically designed for precision measurements in resistance thermometry. The precise ratio of currents flowing through two resistances being compared is obtained from accurate tapped current transformers. The

TABLE D1

Platinum Resistance Thermometer NPL Calibrations

W	t (^{o}C)
1.00	0.0000
1.01	2.5101
1.02	5.0222
1.03	7.5363
1.04	10.0522
1.05	12.5702
1.06	15.0900
1.07	17.6119
1.08	20.1356
1.09	22.6614
1.10	25.1891
1.11	27.7187
1.12	30.2504
1.13	32.7840
1.14	35.3195
1.15	37.8571
1.16	40.3966
1.17	42.9381
1.18	45.4816
1.19	48.0271
1.20	50.5745
1.21	53.1240
1.22	55.6754
1.23	58.2289

bridge uses four-terminal connections and a low working frequency 5 c/s. The bridge has resistance ratio ranges of 0 to 1.111110 and 0 to 11.11110 with comparison accuracy of 1 in 10^5 and a resolution of 1 in 10^6.

D3 THERMOCOUPLE CALIBRATION DATA

The temperatures of the aluminium calibration block as indicated by

(i) the platinum resistance thermometer

(ii) the four thermocouple wires (numbers 5, 23, 33 and 35)

are shown in Table D2.

The temperatures of the water bath as indicated by the mercury-in-glass thermometer are also presented.

D4 THERMOCOUPLE EQUATIONS

Using non-linear regression (least squares parabolic fit), the quadratic equations relating the emf to the temperature were obtained.

(a) for thermocouple wires 5 and 23

$$e = 0.02785736 + 0.03741623T + 0.00004287T^2 \qquad \text{(D-1)}$$

(b) for thermocouple wires 33 and 35

$$e = -0.00726804 + 0.03904908T + 0.00004037T^2 \qquad \text{(D-2)}$$

TABLE D2

Thermocouple Calibration - Raw Experimental Data

Run	Room Temp. °C	Hg-in-glass Thermometer Bath Temp. °C	Thermocouple Wires Millivolt Readings 5 mV	23 mV	33 mV	35 mV	Water Bath Temperature By Platinum Resistance Thermometer: Resistance Ratios R1/R2	R2/R1	Mean Resistance Ratio	Water Bath Temperature °C
1	22.2	25.47	1.031	1.031	1.017	1.017	1.101140	.908191	1.101115	25.5837
2	22.0	25.47	1.017	1.017	1.021	1.021	1.101348	.908004	1.101332	25.6386
3	21.8	25.65	1.023	1.023	1.028	1.028	1.102199	.907327	1.102169	25.8504
4	21.7	25.67	1.024	1.024	1.029	1.029	1.102281	.907274	1.102242	25.8689
5	22.0	27.8	1.109	1.109	1.117	1.117	1.110726	.900362	1.110695	28.0083
6	22.6	27.8	1.109	1.109	1.117	1.117	1.110709	.900376	1.110678	28.0040
7	21.6	28.65	1.14	1.14	1.153	1.153	1.11395	.897953	1.113859	28.8096
8	21.8	28.68	1.14	1.14	1.153	1.153	1.11412	.897667	1.114059	28.8603
9	21.7	29.9	1.192	1.192	1.204	1.204	1.11884	.893896	1.118769	30.0532
10	22.1	29.9	1.192	1.192	1.204	1.204	1.11887	.893860	1.118807	30.0628
11	21.4	31.2	1.247	1.247	1.261	1.26	1.12426	.889567	1.124201	31.4299
12	21.6	31.2	1.247	1.247	1.261	1.261	1.12430	.889541	1.124238	31.4392
13	22.8	33.05	1.323	1.323	1.337	1.337	1.13140	.883967	1.131332	33.2376
14	22.8	33.05	1.322	1.322	1.337	1.337	1.13144	.883930	1.131376	33.2488
15	20.9	35.95	1.435	1.434	1.457	1.456	1.14290	.875063	1.142837	36.1566
16	21.5	35.95	1.437	1.437	1.458	1.458	1.14294	.875024	1.142883	36.1683
17	22.2	38.02	1.522	1.522	1.546	1.546	1.15116	.868820	1.151073	38.2477
18	21.9	38.02	1.521	1.521	1.545	1.545	1.15121	.868772	1.15113	38.2622
19	22.8	40.1	1.611	1.611	1.637	1.637	1.15958	.862504	1.159497	40.3878
20	23.0	40.1	1.612	1.611	1.637	1.637	1.15962	.862468	1.159542	40.3993
21	22.1	40.9	1.638	1.637	1.667	1.667	1.16276	.86014	1.162681	41.1974
22	22.4	40.9	1.639	1.638	1.667	1.667	1.16267	.86022	1.162582	41.1722
23	21.0	42	1.688	1.688	1.718	1.718	1.16712	.856934	1.167036	42.3046
24	22.1	42	1.690	1.689	1.718	1.718	1.16715	.856894	1.167078	42.3153
25	22.2	43	1.730	1.73	1.761	1.761	1.17119	.853935	1.17112	43.3433
26	22.3	43.02	1.729	1.728	1.759	1.759	1.17119	.853943	1.171114	43.3418
27	22.3	44	1.770	1.769	1.802	1.803	1.17503	.851149	1.174956	44.3194
28	22.3	44	1.770	1.769	1.802	1.802	1.17502	.851166	1.174939	44.3151
29	22.3	44.9	1.813	1.811	1.846	1.846	1.17885	.848429	1.178750	45.2848
30	22.8	44.9	1.813	1.812	1.845	1.845	1.17883	.848421	1.178745	45.2835
31	22.8	46.1	1.857	1.855	1.890	1.891	1.18307	.845338	1.183014	46.3705
32	22.7	46.05	1.855	1.854	1.889	1.889	1.18307	.845372	1.182991	46.3646
33	22.3	49.95	2.016	2.016	2.058	2.058	1.19859	.834434	1.198504	50.3158
34	22.0	50	2.019	2.018	2.058	2.058	1.19858	.834467	1.198475	50.3094
35	23.0	54.9	2.228	2.225	2.274	2.274	1.21787	.821208	1.217794	55.2381
36	22.9	54.9	2.227	2.225	2.274	2.274	1.21786	.821213	1.217785	55.2358

D5 THERMOCOUPLE TABLES

TABLE D3

COPPER VERSUS CONSTANTAN THERMOCOUPLE
DEGREES CELSIUS

PLATINUM-RESISTANCE THERMOMETER CALIBRATION DATA

THERMOCOUPLE WIRES 5 AND 23

MILLIVOLTS

	0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9
0	0,028	0,032	0,035	0,039	0,043	0,047	0,050	0,054	0,058	0,062
1	0,065	0,069	0,073	0,077	0,080	0,084	0,088	0,092	0,095	0,099
2	0.103	0,107	0,110	0,114	0,118	0,122	0,125	0,129	0,133	0,137
3	0.140	0,144	0,148	0,152	0,156	0,159	0,163	0,167	0,171	0,174
4	0.178	0,182	0,186	0,190	0,193	0,197	0,201	0,205	0,208	0,212
5	0,216	0,220	0,224	0,227	0,231	0,235	0,239	0,243	0,246	0,250
6	0.254	0,258	0,261	0,265	0,269	0,273	0,277	0,280	0,284	0,288
7	0,292	0,296	0,299	0,303	0,307	0,311	0,315	0,319	0,322	0,326
8	0,330	0,334	0,338	0,341	0,345	0,349	0,353	0,357	0,360	0,364
9	0,368	0,372	0,376	0,380	0,383	0,387	0,391	0,395	0,399	0,402
10	0,406	0,410	0,414	0,418	0,422	0,425	0,429	0,433	0,437	0,441
11	0,445	0,448	0,452	0,456	0,460	0,464	0,468	0,471	0,475	0,479
12	0,483	0,487	0,491	0,495	0,498	0,502	0,506	0,510	0,514	0,518
13	0,522	0,525	0,529	0,533	0,537	0,541	0,545	0,549	0,552	0,556
14	0,560	0,564	0,568	0,572	0,576	0,579	0,583	0,587	0,591	0,595
15	0,599	0,603	0,606	0,610	0,614	0,618	0,622	0,626	0,630	0,634
16	0,637	0,641	0,645	0,649	0,653	0,657	0,661	0,665	0,669	0,672
17	0,676	0,680	0,684	0,688	0,692	0,696	0,700	0,704	0,707	0,711
18	0,715	0,719	0,723	0,727	0,731	0,735	0,739	0,743	0,746	0,750
19	0,754	0,758	0,762	0,766	0,770	0,774	0,778	0,782	0,786	0,789
20	0,793	0,797	0,801	0,805	0,809	0,813	0,817	0,821	0,825	0,829
21	0,833	0,836	0,840	0,844	0,848	0,852	0,856	0,860	0,864	0,868
22	0,872	0,876	0,880	0,884	0,887	0,891	0,895	0,899	0,903	0,907
23	0,911	0,915	0,919	0,923	0,927	0,931	0,935	0,939	0,943	0,947
24	0,951	0,954	0,958	0,962	0,966	0,970	0,974	0,978	0,982	0,986
25	0,990	0,994	0,998	1,002	1,006	1,010	1,014	1,018	1,022	1,026
26	1,030	1,034	1,038	1,042	1,045	1,049	1,053	1,057	1,061	1,065
27	1,069	1,073	1,077	1,081	1,085	1,089	1,093	1,097	1,101	1,105
28	1,109	1,113	1,117	1,121	1,125	1,129	1,133	1,137	1,141	1,145
29	1,149	1,153	1,157	1,161	1,165	1,169	1,173	1,177	1,181	1,185
30	1,189	1,193	1,197	1,201	1,205	1,209	1,213	1,217	1,221	1,225
31	1,229	1,233	1,237	1,241	1,245	1,249	1,253	1,257	1,261	1,265
32	1,269	1,273	1,277	1,281	1,285	1,289	1,293	1,297	1,301	1,305
33	1,309	1,313	1,317	1,321	1,325	1,329	1,333	1,337	1,342	1,346
34	1,350	1,354	1,358	1,362	1,366	1,370	1,374	1,378	1,382	1,386
35	1,390	1,394	1,398	1,402	1,406	1,410	1,414	1,418	1,422	1,426
36	1,430	1,434	1,439	1,443	1,447	1,451	1,455	1,459	1,463	1,467
37	1,471	1,475	1,479	1,483	1,487	1,491	1,495	1,499	1,503	1,508
38	1,512	1,516	1,520	1,524	1,528	1,532	1,536	1,540	1,544	1,548
39	1,552	1,556	1,560	1,565	1,569	1,573	1,577	1,581	1,585	1,589
40	1,593	1,597	1,601	1,605	1,609	1,614	1,618	1,622	1,626	1,630
41	1,634	1,638	1,642	1,646	1,650	1,654	1,659	1,663	1,667	1,671
42	1,675	1,679	1,683	1,687	1,691	1,695	1,700	1,704	1,708	1,712
43	1,716	1,720	1,724	1,728	1,732	1,737	1,741	1,745	1,749	1,753
44	1,757	1,761	1,765	1,770	1,774	1,778	1,782	1,786	1,790	1,794
45	1,798	1,803	1,807	1,811	1,815	1,819	1,823	1,827	1,831	1,836
46	1,840	1,844	1,848	1,852	1,856	1,860	1,865	1,869	1,873	1,877
47	1,881	1,885	1,889	1,894	1,898	1,902	1,906	1,910	1,914	1,918
48	1,923	1,927	1,931	1,935	1,939	1,943	1,948	1,952	1,956	1,960
49	1,964	1,968	1,973	1,977	1,981	1,985	1,989	1,993	1,998	2,002
50	2,006	2,010	2,014	2,018	2,023	2,027	2,031	2,035	2,039	2,043
51	2,048	2,052	2,056	2,060	2,064	2,068	2,073	2,077	2,081	2,085
52	2,089	2,094	2,098	2,102	2,106	2,110	2,115	2,119	2,123	2,127
53	2,131	2,136	2,140	2,144	2,148	2,152	2,157	2,161	2,165	2,169
54	2,173	2,178	2,182	2,186	2,190	2,194	2,199	2,203	2,207	2,211
55	2,215	2,220	2,224	2,228	2,232	2,237	2,241	2,245	2,249	2,253
56	2,258	2,262	2,266	2,270	2,275	2,279	2,283	2,287	2,291	2,296
57	2,300	2,304	2,308	2,313	2,317	2,321	2,325	2,330	2,334	2,338
58	2,342	2,346	2,351	2,355	2,359	2,363	2,368	2,372	2,376	2,380
59	2,385	2,389	2,393	2,397	2,402	2,406	2,410	2,414	2,419	2,423
60	2,427	2,431	2,436	2,440	2,444	2,448	2,453	2,457	2,451	2,466
61	2,470	2,474	2,478	2,483	2,487	2,491	2,495	2,500	2,504	2,508
62	2,512	2,517	2,521	2,525	2,530	2,534	2,538	2,542	2,547	2,551
63	2,555	2,560	2,564	2,568	2,572	2,577	2,581	2,585	2,590	2,594
64	2,598	2,602	2,607	2,611	2,615	2,620	2,624	2,628	2,632	2,637
65	2,641	2,645	2,650	2,654	2,658	2,663	2,667	2,671	2,675	2,680
66	2,684	2,688	2,693	2,697	2,701	2,706	2,710	2,714	2,719	2,723
67	2,727	2,732	2,736	2,740	2,744	2,749	2,753	2,757	2,762	2,766
68	2,770	2,775	2,779	2,783	2,788	2,792	2,796	2,801	2,805	2,809
69	2,814	2,818	2,822	2,827	2,831	2,835	2,840	2,844	2,848	2,853
70	2,857	2,861	2,866	2,870	2,874	2,879	2,883	2,887	2,892	2,896
71	2,901	2,905	2,909	2,914	2,918	2,922	2,927	2,931	2,935	2,940
72	2,944	2,948	2,953	2,957	2,962	2,966	2,970	2,975	2,979	2,983
73	2,988	2,992	2,996	3,001	3,005	3,010	3,014	3,018	3,023	3,027
74	3,031	3,036	3,040	3,045	3,049	3,053	3,058	3,062	3,066	3,071
75	3,075	3,080	3,084	3,088	3,093	3,097	3,102	3,106	3,110	3,115
76	3,119	3,124	3,128	3,132	3,137	3,141	3,145	3,150	3,154	3,159
77	3,163	3,167	3,172	3,176	3,181	3,185	3,190	3,194	3,198	3,203
78	3,207	3,212	3,216	3,220	3,225	3,229	3,234	3,238	3,242	3,247
79	3,251	3,256	3,260	3,265	3,269	3,273	3,278	3,282	3,287	3,291
80	3,296	3,300	3,304	3,309	3,313	3,318	3,322	3,327	3,331	3,335
81	3,340	3,344	3,349	3,353	3,358	3,362	3,366	3,371	3,375	3,380
82	3,384	3,389	3,393	3,398	3,402	3,406	3,411	3,415	3,420	3,424
83	3,429	3,433	3,438	3,442	3,447	3,451	3,455	3,460	3,464	3,469
84	3,473	3,478	3,482	3,487	3,491	3,496	3,500	3,505	3,509	3,514
85	3,518	3,522	3,527	3,531	3,536	3,540	3,545	3,549	3,554	3,558
86	3,563	3,567	3,572	3,576	3,581	3,585	3,590	3,594	3,599	3,603
87	3,608	3,612	3,617	3,621	3,626	3,630	3,634	3,639	3,643	3,648
88	3,652	3,657	3,661	3,666	3,670	3,675	3,679	3,684	3,688	3,693
89	3,697	3,702	3,706	3,711	3,716	3,720	3,725	3,729	3,734	3,738
90	3,743	3,747	3,752	3,756	3,761	3,765	3,770	3,774	3,779	3,783
91	3,788	3,792	3,797	3,801	3,806	3,810	3,815	3,819	3,824	3,828
92	3,833	3,838	3,842	3,847	3,851	3,856	3,860	3,865	3,869	3,874
93	3,878	3,883	3,887	3,892	3,897	3,901	3,906	3,910	3,915	3,919
94	3,924	3,928	3,933	3,937	3,942	3,947	3,951	3,956	3,960	3,965
95	3,969	3,974	3,978	3,983	3,988	3,992	3,997	4,001	4,006	4,010
96	4,015	4,019	4,024	4,029	4,033	4,038	4,042	4,047	4,051	4,056
97	4,061	4,065	4,070	4,074	4,079	4,083	4,088	4,093	4,097	4,102
98	4,106	4,111	4,116	4,120	4,125	4,129	4,134	4,138	4,143	4,148
99	4,152	4,157	4,161	4,166	4,171	4,175	4,180	4,184	4,189	4,194
100	4,198	4,203	4,207	4,212	4,217	4,221	4,226	4,230	4,235	4,240

TABLE D3 (continued)

99	4.152	4.157	4.161	4.166	4.171	4.175	4.180	4.184	4.189	4.194
100	4.198	4.203	4.207	4.212	4.217	4.221	4.226	4.230	4.235	4.240
101	4.244	4.249	4.253	4.258	4.263	4.267	4.272	4.276	4.281	4.286
102	4.290	4.295	4.300	4.304	4.309	4.313	4.318	4.323	4.327	4.332
103	4.337	4.341	4.346	4.350	4.355	4.360	4.364	4.369	4.374	4.378
104	4.383	4.387	4.392	4.397	4.401	4.406	4.411	4.415	4.420	4.425
105	4.429	4.434	4.438	4.443	4.448	4.452	4.457	4.462	4.466	4.471
106	4.476	4.480	4.485	4.490	4.494	4.499	4.504	4.508	4.513	4.518
107	4.522	4.527	4.532	4.536	4.541	4.546	4.550	4.555	4.560	4.564
108	4.569	4.574	4.578	4.583	4.588	4.592	4.597	4.602	4.606	4.611
109	4.616	4.620	4.625	4.630	4.634	4.639	4.644	4.648	4.653	4.658
110	4.662	4.667	4.672	4.676	4.681	4.686	4.690	4.695	4.700	4.705
111	4.709	4.714	4.719	4.723	4.728	4.733	4.737	4.742	4.747	4.752
112	4.756	4.761	4.766	4.770	4.775	4.780	4.784	4.789	4.794	4.799
113	4.803	4.808	4.813	4.817	4.822	4.827	4.832	4.836	4.841	4.846
114	4.850	4.855	4.860	4.865	4.869	4.874	4.879	4.884	4.888	4.893
115	4.898	4.902	4.907	4.912	4.917	4.921	4.926	4.931	4.936	4.940
116	4.945	4.950	4.954	4.959	4.964	4.969	4.973	4.978	4.983	4.988
117	4.992	4.997	5.002	5.007	5.011	5.016	5.021	5.026	5.030	5.035
118	5.040	5.045	5.049	5.054	5.059	5.064	5.068	5.073	5.078	5.083
119	5.087	5.092	5.097	5.102	5.107	5.111	5.116	5.121	5.126	5.130
120	5.135	5.140	5.145	5.149	5.154	5.159	5.164	5.169	5.173	5.178
121	5.183	5.188	5.192	5.197	5.202	5.207	5.212	5.216	5.221	5.226
122	5.231	5.236	5.240	5.245	5.250	5.255	5.259	5.264	5.269	5.274
123	5.279	5.283	5.288	5.293	5.298	5.303	5.307	5.312	5.317	5.322
124	5.327	5.331	5.336	5.341	5.346	5.351	5.355	5.360	5.365	5.370
125	5.375	5.380	5.384	5.389	5.394	5.399	5.404	5.408	5.413	5.418
126	5.423	5.428	5.433	5.437	5.442	5.447	5.452	5.457	5.462	5.466
127	5.471	5.476	5.481	5.486	5.490	5.495	5.500	5.505	5.510	5.515
128	5.520	5.524	5.529	5.534	5.539	5.544	5.549	5.553	5.558	5.563
129	5.568	5.573	5.578	5.582	5.587	5.592	5.597	5.602	5.607	5.612
130	5.616	5.621	5.626	5.631	5.636	5.641	5.646	5.650	5.655	5.660
131	5.665	5.670	5.675	5.680	5.685	5.689	5.694	5.699	5.704	5.709
132	5.714	5.719	5.724	5.728	5.733	5.738	5.743	5.748	5.753	5.758
133	5.763	5.767	5.772	5.777	5.782	5.787	5.792	5.797	5.802	5.807
134	5.811	5.816	5.821	5.826	5.831	5.836	5.841	5.846	5.851	5.855
135	5.860	5.865	5.870	5.875	5.880	5.885	5.890	5.895	5.900	5.904
136	5.909	5.914	5.919	5.924	5.929	5.934	5.939	5.944	5.949	5.954
137	5.959	5.963	5.968	5.973	5.978	5.983	5.988	5.993	5.998	6.003
138	6.008	6.013	6.018	6.022	6.027	6.032	6.037	6.042	6.047	6.052
139	6.057	6.062	6.067	6.072	6.077	6.082	6.087	6.092	6.096	6.101
140	6.106	6.111	6.116	6.121	6.126	6.131	6.136	6.141	6.146	6.151
141	6.156	6.161	6.166	6.171	6.176	6.181	6.186	6.191	6.195	6.200
142	6.205	6.210	6.215	6.220	6.225	6.230	6.235	6.240	6.245	6.250
143	6.255	6.260	6.265	6.270	6.275	6.280	6.285	6.290	6.295	6.300
144	6.305	6.310	6.315	6.320	6.325	6.330	6.335	6.340	6.345	6.350
145	6.355	6.360	6.365	6.370	6.374	6.379	6.384	6.389	6.394	6.399
146	6.404	6.409	6.414	6.419	6.424	6.429	6.434	6.439	6.444	6.449
147	6.454	6.459	6.464	6.469	6.474	6.479	6.484	6.489	6.494	6.499
148	6.504	6.509	6.515	6.520	6.525	6.530	6.535	6.540	6.545	6.550
149	6.555	6.560	6.565	6.570	6.575	6.580	6.585	6.590	6.595	6.600
150	6.605	6.610	6.615	6.620	6.625	6.630	6.635	6.640	6.645	6.650
151	6.655	6.660	6.665	6.670	6.675	6.680	6.685	6.690	6.696	6.701
152	6.706	6.711	6.716	6.721	6.726	6.731	6.736	6.741	6.746	6.751
153	6.756	6.761	6.766	6.771	6.776	6.781	6.786	6.791	6.797	6.802
154	6.807	6.812	6.817	6.822	6.827	6.832	6.837	6.842	6.847	6.852
155	6.857	6.862	6.867	6.873	6.878	6.883	6.888	6.893	6.898	6.903
156	6.908	6.913	6.918	6.923	6.928	6.933	6.939	6.944	6.949	6.954
157	6.959	6.964	6.969	6.974	6.979	6.984	6.989	6.995	7.000	7.005
158	7.010	7.015	7.020	7.025	7.030	7.035	7.040	7.046	7.051	7.056
159	7.061	7.066	7.071	7.076	7.081	7.086	7.091	7.097	7.102	7.107
160	7.112	7.117	7.122	7.127	7.132	7.138	7.143	7.148	7.153	7.158
161	7.163	7.168	7.173	7.178	7.184	7.189	7.194	7.199	7.204	7.209
162	7.214	7.219	7.225	7.230	7.235	7.240	7.245	7.250	7.255	7.261
163	7.266	7.271	7.276	7.281	7.286	7.291	7.297	7.302	7.307	7.312
164	7.317	7.322	7.327	7.333	7.338	7.343	7.348	7.353	7.358	7.364
165	7.369	7.374	7.379	7.384	7.389	7.394	7.400	7.405	7.410	7.415
166	7.420	7.425	7.431	7.436	7.441	7.446	7.451	7.456	7.462	7.467
167	7.472	7.477	7.482	7.487	7.493	7.498	7.503	7.508	7.513	7.519
168	7.524	7.529	7.534	7.539	7.544	7.550	7.555	7.560	7.565	7.570
169	7.576	7.581	7.586	7.591	7.596	7.602	7.607	7.612	7.617	7.622
170	7.628	7.633	7.638	7.643	7.648	7.654	7.659	7.664	7.669	7.674
171	7.680	7.685	7.690	7.695	7.700	7.706	7.711	7.716	7.721	7.726
172	7.732	7.737	7.742	7.747	7.753	7.758	7.763	7.768	7.773	7.779
173	7.784	7.789	7.794	7.800	7.805	7.810	7.815	7.821	7.826	7.831
174	7.836	7.841	7.847	7.852	7.857	7.862	7.868	7.873	7.878	7.883
175	7.889	7.894	7.899	7.904	7.910	7.915	7.920	7.925	7.931	7.936
176	7.941	7.946	7.952	7.957	7.962	7.967	7.973	7.978	7.983	7.988
177	7.994	7.999	8.004	8.009	8.015	8.020	8.025	8.030	8.036	8.041
178	8.046	8.052	8.057	8.062	8.067	8.073	8.078	8.083	8.088	8.094
179	8.099	8.104	8.110	8.115	8.120	8.125	8.131	8.136	8.141	8.146
180	8.152	8.157	8.162	8.168	8.173	8.178	8.183	8.189	8.194	8.199
181	8.205	8.210	8.215	8.221	8.226	8.231	8.236	8.242	8.247	8.252
182	8.258	8.263	8.268	8.274	8.279	8.284	8.289	8.295	8.300	8.305
183	8.311	8.316	8.321	8.327	8.332	8.337	8.343	8.348	8.353	8.359
184	8.364	8.369	8.374	8.380	8.385	8.390	8.396	8.401	8.406	8.412
185	8.417	8.422	8.428	8.433	8.438	8.444	8.449	8.454	8.460	8.465
186	8.470	8.476	8.481	8.486	8.492	8.497	8.502	8.508	8.513	8.518
187	8.524	8.529	8.535	8.540	8.545	8.551	8.556	8.561	8.567	8.572
188	8.577	8.583	8.588	8.593	8.599	8.604	8.609	8.615	8.620	8.626
189	8.631	8.636	8.642	8.647	8.652	8.658	8.663	8.668	8.674	8.679
190	8.685	8.690	8.695	8.701	8.706	8.711	8.717	8.722	8.728	8.733
191	8.738	8.744	8.749	8.754	8.760	8.765	8.771	8.776	8.781	8.787
192	8.792	8.798	8.803	8.808	8.814	8.819	8.824	8.830	8.835	8.841
193	8.846	8.851	8.857	8.862	8.868	8.873	8.878	8.884	8.889	8.895
194	8.900	8.905	8.911	8.916	8.922	8.927	8.933	8.938	8.943	8.949
195	8.954	8.960	8.965	8.970	8.976	8.981	8.987	8.992	8.997	9.003
196	9.008	9.014	9.019	9.025	9.030	9.035	9.041	9.046	9.052	9.057
197	9.063	9.068	9.073	9.079	9.084	9.090	9.095	9.101	9.106	9.112
198	9.117	9.122	9.128	9.133	9.139	9.144	9.150	9.155	9.160	9.166
199	9.171	9.177	9.182	9.188	9.193	9.199	9.204	9.210	9.215	9.220
200	9.226	9.231	9.237	9.242	9.248	9.253	9.259	9.264	9.270	9.275

TABLE D4

COPPER VERSUS CONSTANTAN THERMOCOUPLE
DEGREES CELSIUS
PLATINUM-RESISTANCE THERMOMETER CALIBRATIONDATA
THERMOCOUPLE WIRES 33 AND 35

MILLIVOLTS

	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	-0.007	-0.003	0.001	0.004	0.008	0.012	0.016	0.020	0.024	0.028
1	0.032	0.036	0.040	0.044	0.047	0.051	0.055	0.059	0.063	0.067
2	0.071	0.075	0.079	0.083	0.087	0.091	0.095	0.098	0.102	0.106
3	0.110	0.114	0.118	0.122	0.126	0.130	0.134	0.138	0.142	0.146
4	0.150	0.154	0.157	0.161	0.165	0.169	0.173	0.177	0.181	0.185
5	0.189	0.193	0.197	0.201	0.205	0.209	0.213	0.217	0.221	0.225
6	0.228	0.232	0.236	0.240	0.244	0.248	0.252	0.256	0.260	0.264
7	0.268	0.272	0.276	0.280	0.284	0.288	0.292	0.296	0.300	0.304
8	0.308	0.312	0.316	0.320	0.324	0.328	0.332	0.336	0.339	0.343
9	0.347	0.351	0.355	0.359	0.363	0.367	0.371	0.375	0.379	0.383
10	0.387	0.391	0.395	0.399	0.403	0.407	0.411	0.415	0.419	0.423
11	0.427	0.431	0.435	0.439	0.443	0.447	0.451	0.455	0.459	0.463
12	0.467	0.471	0.475	0.479	0.483	0.487	0.491	0.495	0.499	0.503
13	0.507	0.511	0.515	0.519	0.523	0.527	0.531	0.535	0.539	0.543
14	0.547	0.551	0.555	0.559	0.563	0.567	0.571	0.575	0.580	0.584
15	0.588	0.592	0.596	0.600	0.604	0.608	0.612	0.616	0.620	0.624
16	0.628	0.632	0.636	0.640	0.644	0.648	0.652	0.656	0.660	0.664
17	0.668	0.672	0.676	0.680	0.684	0.688	0.693	0.697	0.701	0.705
18	0.709	0.713	0.717	0.721	0.725	0.729	0.733	0.737	0.741	0.745
19	0.749	0.753	0.757	0.761	0.765	0.770	0.774	0.778	0.782	0.786
20	0.790	0.794	0.798	0.802	0.806	0.810	0.814	0.818	0.822	0.826
21	0.831	0.835	0.839	0.843	0.847	0.851	0.855	0.859	0.863	0.867
22	0.871	0.875	0.880	0.884	0.888	0.892	0.896	0.900	0.904	0.908
23	0.912	0.916	0.920	0.924	0.929	0.933	0.937	0.941	0.945	0.949
24	0.953	0.957	0.961	0.965	0.970	0.974	0.978	0.982	0.986	0.990
25	0.994	0.998	1.002	1.007	1.011	1.015	1.019	1.023	1.027	1.031
26	1.035	1.039	1.044	1.048	1.052	1.056	1.060	1.064	1.068	1.072
27	1.076	1.081	1.085	1.089	1.093	1.097	1.101	1.105	1.109	1.114
28	1.118	1.122	1.126	1.130	1.134	1.138	1.143	1.147	1.151	1.155
29	1.159	1.163	1.167	1.172	1.176	1.180	1.184	1.188	1.192	1.196
30	1.201	1.205	1.209	1.213	1.217	1.221	1.225	1.230	1.234	1.238
31	1.242	1.246	1.250	1.255	1.259	1.263	1.267	1.271	1.275	1.279
32	1.284	1.288	1.292	1.296	1.300	1.304	1.309	1.313	1.317	1.321
33	1.325	1.329	1.334	1.338	1.342	1.346	1.350	1.355	1.359	1.363
34	1.367	1.371	1.375	1.380	1.384	1.388	1.392	1.396	1.401	1.405
35	1.409	1.413	1.417	1.421	1.426	1.430	1.434	1.438	1.442	1.447
36	1.451	1.455	1.459	1.463	1.468	1.472	1.476	1.480	1.484	1.489
37	1.493	1.497	1.501	1.505	1.510	1.514	1.518	1.522	1.526	1.531
38	1.535	1.539	1.543	1.548	1.552	1.556	1.560	1.564	1.569	1.573
39	1.577	1.581	1.585	1.590	1.594	1.598	1.602	1.607	1.611	1.615
40	1.619	1.624	1.628	1.632	1.636	1.640	1.645	1.649	1.653	1.657
41	1.662	1.666	1.670	1.674	1.679	1.683	1.687	1.691	1.696	1.700
42	1.704	1.708	1.712	1.717	1.721	1.725	1.729	1.734	1.738	1.742
43	1.746	1.751	1.755	1.759	1.764	1.768	1.772	1.776	1.781	1.785
44	1.789	1.793	1.798	1.802	1.806	1.810	1.815	1.819	1.823	1.827
45	1.832	1.836	1.840	1.844	1.849	1.853	1.857	1.862	1.866	1.870
46	1.874	1.879	1.883	1.887	1.892	1.896	1.900	1.904	1.909	1.913
47	1.917	1.922	1.926	1.930	1.934	1.939	1.943	1.947	1.952	1.956
48	1.960	1.964	1.969	1.973	1.977	1.982	1.986	1.990	1.994	1.999
49	2.003	2.007	2.012	2.016	2.020	2.025	2.029	2.033	2.037	2.042
50	2.046	2.050	2.055	2.059	2.063	2.068	2.072	2.076	2.081	2.085
51	2.089	2.094	2.098	2.102	2.107	2.111	2.115	2.119	2.124	2.128
52	2.132	2.137	2.141	2.145	2.150	2.154	2.158	2.163	2.167	2.171
53	2.176	2.180	2.184	2.189	2.193	2.197	2.202	2.206	2.210	2.215
54	2.219	2.223	2.228	2.232	2.236	2.241	2.245	2.250	2.254	2.258
55	2.263	2.267	2.271	2.276	2.280	2.284	2.289	2.293	2.297	2.302
56	2.306	2.310	2.315	2.319	2.324	2.328	2.332	2.337	2.341	2.345
57	2.350	2.354	2.358	2.363	2.367	2.372	2.376	2.380	2.385	2.389
58	2.393	2.398	2.402	2.407	2.411	2.415	2.420	2.424	2.428	2.433
59	2.437	2.442	2.446	2.450	2.455	2.459	2.463	2.468	2.472	2.477
60	2.481	2.485	2.490	2.494	2.499	2.503	2.507	2.512	2.516	2.521
61	2.525	2.529	2.534	2.538	2.543	2.547	2.551	2.556	2.560	2.565
62	2.569	2.573	2.578	2.582	2.587	2.591	2.595	2.600	2.604	2.609
63	2.613	2.617	2.622	2.626	2.631	2.635	2.640	2.644	2.648	2.653
64	2.657	2.662	2.666	2.670	2.675	2.679	2.684	2.688	2.693	2.697
65	2.701	2.706	2.710	2.715	2.719	2.724	2.728	2.733	2.737	2.741
66	2.746	2.750	2.755	2.759	2.764	2.768	2.772	2.777	2.781	2.786
67	2.790	2.795	2.799	2.804	2.808	2.812	2.817	2.821	2.826	2.830
68	2.835	2.839	2.844	2.848	2.853	2.857	2.861	2.866	2.870	2.875
69	2.879	2.884	2.888	2.893	2.897	2.902	2.906	2.911	2.915	2.920
70	2.924	2.928	2.933	2.937	2.942	2.946	2.951	2.955	2.960	2.964
71	2.969	2.973	2.978	2.982	2.987	2.991	2.996	3.000	3.005	3.009
72	3.014	3.018	3.023	3.027	3.031	3.036	3.040	3.045	3.049	3.054
73	3.058	3.063	3.067	3.072	3.076	3.081	3.085	3.090	3.094	3.099
74	3.103	3.108	3.112	3.117	3.121	3.126	3.130	3.135	3.139	3.144
75	3.148	3.153	3.158	3.162	3.167	3.171	3.176	3.180	3.185	3.189
76	3.194	3.198	3.203	3.207	3.212	3.216	3.221	3.225	3.230	3.234
77	3.239	3.243	3.248	3.252	3.257	3.262	3.266	3.271	3.275	3.280
78	3.284	3.289	3.293	3.298	3.302	3.307	3.311	3.316	3.320	3.325
79	3.330	3.334	3.339	3.343	3.348	3.352	3.357	3.361	3.366	3.370
80	3.375	3.380	3.384	3.389	3.393	3.398	3.402	3.407	3.411	3.416
81	3.421	3.425	3.430	3.434	3.439	3.443	3.448	3.453	3.457	3.462
82	3.466	3.471	3.475	3.480	3.484	3.489	3.494	3.498	3.503	3.507
83	3.512	3.516	3.521	3.526	3.530	3.535	3.539	3.544	3.549	3.553
84	3.558	3.562	3.567	3.571	3.576	3.581	3.585	3.590	3.594	3.599
85	3.604	3.608	3.613	3.617	3.622	3.627	3.631	3.636	3.640	3.645
86	3.650	3.654	3.659	3.663	3.668	3.673	3.677	3.682	3.686	3.691
87	3.696	3.700	3.705	3.709	3.714	3.719	3.723	3.728	3.732	3.737
88	3.742	3.746	3.751	3.756	3.760	3.765	3.769	3.774	3.779	3.783
89	3.788	3.792	3.797	3.802	3.806	3.811	3.816	3.820	3.825	3.830
90	3.834	3.839	3.843	3.848	3.853	3.857	3.862	3.867	3.871	3.876
91	3.881	3.885	3.890	3.894	3.899	3.904	3.908	3.913	3.918	3.922
92	3.927	3.932	3.936	3.941	3.946	3.950	3.955	3.959	3.964	3.969
93	3.973	3.978	3.983	3.987	3.992	3.997	4.001	4.006	4.011	4.015
94	4.020	4.025	4.029	4.034	4.039	4.043	4.048	4.053	4.057	4.062
95	4.067	4.071	4.076	4.081	4.085	4.090	4.095	4.099	4.104	4.109
96	4.113	4.118	4.123	4.128	4.132	4.137	4.142	4.146	4.151	4.156
97	4.160	4.165	4.170	4.174	4.179	4.184	4.188	4.193	4.198	4.203
98	4.207	4.212	4.217	4.221	4.226	4.231	4.235	4.240	4.245	4.250
99	4.254	4.259	4.264	4.268	4.273	4.278	4.282	4.287	4.292	4.297
100	4.301	4.306	4.311	4.315	4.320	4.325	4.330	4.334	4.339	4.344

TABLE D4 (continued)

99	4.254	4.259	4.264	4.268	4.273	4.278	4.282	4.287	4.292	4.297
100	4.301	4.306	4.311	4.315	4.320	4.325	4.330	4.334	4.339	4.344
101	4.349	4.353	4.358	4.363	4.367	4.372	4.377	4.382	4.386	4.391
102	4.396	4.400	4.405	4.410	4.415	4.419	4.424	4.429	4.434	4.438
103	4.443	4.448	4.453	4.457	4.462	4.467	4.472	4.476	4.481	4.486
104	4.490	4.495	4.500	4.505	4.509	4.514	4.519	4.524	4.528	4.533
105	4.538	4.543	4.547	4.552	4.557	4.562	4.566	4.571	4.576	4.581
106	4.586	4.590	4.595	4.600	4.605	4.609	4.614	4.619	4.624	4.628
107	4.633	4.638	4.643	4.647	4.652	4.657	4.662	4.667	4.671	4.676
108	4.681	4.686	4.690	4.695	4.700	4.705	4.710	4.714	4.719	4.724
109	4.729	4.734	4.738	4.743	4.748	4.753	4.757	4.762	4.767	4.772
110	4.777	4.781	4.786	4.791	4.796	4.801	4.805	4.810	4.815	4.820
111	4.825	4.829	4.834	4.839	4.844	4.849	4.853	4.858	4.863	4.868
112	4.873	4.877	4.882	4.887	4.892	4.897	4.901	4.906	4.911	4.916
113	4.921	4.926	4.930	4.935	4.940	4.945	4.950	4.955	4.959	4.964
114	4.969	4.974	4.979	4.983	4.988	4.993	4.998	5.003	5.008	5.012
115	5.017	5.022	5.027	5.032	5.037	5.041	5.046	5.051	5.056	5.061
116	5.066	5.070	5.075	5.080	5.085	5.090	5.095	5.100	5.104	5.109
117	5.114	5.119	5.124	5.129	5.134	5.138	5.143	5.148	5.153	5.158
118	5.163	5.167	5.172	5.177	5.182	5.187	5.192	5.197	5.202	5.206
119	5.211	5.216	5.221	5.226	5.231	5.236	5.240	5.245	5.250	5.255
120	5.260	5.265	5.270	5.275	5.279	5.284	5.289	5.294	5.299	5.304
121	5.309	5.314	5.318	5.323	5.328	5.333	5.338	5.343	5.348	5.353
122	5.358	5.362	5.367	5.372	5.377	5.382	5.387	5.392	5.397	5.402
123	5.407	5.411	5.416	5.421	5.426	5.431	5.436	5.441	5.446	5.451
124	5.456	5.460	5.465	5.470	5.475	5.480	5.485	5.490	5.495	5.500
125	5.505	5.510	5.514	5.519	5.524	5.529	5.534	5.539	5.544	5.549
126	5.554	5.559	5.564	5.569	5.574	5.578	5.583	5.588	5.593	5.598
127	5.603	5.608	5.613	5.618	5.623	5.628	5.633	5.638	5.643	5.647
128	5.652	5.657	5.662	5.667	5.672	5.677	5.682	5.687	5.692	5.697
129	5.702	5.707	5.712	5.717	5.722	5.727	5.732	5.737	5.741	5.746
130	5.751	5.756	5.761	5.766	5.771	5.776	5.781	5.786	5.791	5.796
131	5.801	5.806	5.811	5.816	5.821	5.826	5.831	5.836	5.841	5.846
132	5.851	5.856	5.861	5.866	5.871	5.875	5.880	5.885	5.890	5.895
133	5.900	5.905	5.910	5.915	5.920	5.925	5.930	5.935	5.940	5.945
134	5.950	5.955	5.960	5.965	5.970	5.975	5.980	5.985	5.990	5.995
135	6.000	6.005	6.010	6.015	6.020	6.025	6.030	6.035	6.040	6.045
136	6.050	6.055	6.060	6.065	6.070	6.075	6.080	6.085	6.090	6.095
137	6.100	6.105	6.110	6.115	6.120	6.125	6.130	6.135	6.140	6.145
138	6.150	6.155	6.160	6.165	6.170	6.175	6.180	6.185	6.190	6.196
139	6.201	6.206	6.211	6.216	6.221	6.226	6.231	6.236	6.241	6.246
140	6.251	6.256	6.261	6.266	6.271	6.276	6.281	6.286	6.291	6.296
141	6.301	6.306	6.311	6.316	6.321	6.326	6.332	6.337	6.342	6.347
142	6.352	6.357	6.362	6.367	6.372	6.377	6.382	6.387	6.392	6.397
143	6.402	6.407	6.412	6.417	6.423	6.428	6.433	6.438	6.443	6.448
144	6.453	6.458	6.463	6.468	6.473	6.478	6.483	6.488	6.493	6.499
145	6.504	6.509	6.514	6.519	6.524	6.529	6.534	6.539	6.544	6.549
146	6.554	6.560	6.565	6.570	6.575	6.580	6.585	6.590	6.595	6.600
147	6.605	6.610	6.615	6.621	6.626	6.631	6.636	6.641	6.646	6.651
148	6.656	6.661	6.666	6.672	6.677	6.682	6.687	6.692	6.697	6.702
149	6.707	6.712	6.718	6.723	6.728	6.733	6.738	6.743	6.748	6.753
150	6.758	6.764	6.769	6.774	6.779	6.784	6.789	6.794	6.799	6.804
151	6.810	6.815	6.820	6.825	6.830	6.835	6.840	6.846	6.851	6.856
152	6.861	6.866	6.871	6.876	6.881	6.887	6.892	6.897	6.902	6.907
153	6.912	6.917	6.923	6.928	6.933	6.938	6.943	6.948	6.953	6.959
154	6.964	6.969	6.974	6.979	6.984	6.989	6.995	7.000	7.005	7.010
155	7.015	7.020	7.026	7.031	7.036	7.041	7.046	7.051	7.057	7.062
156	7.067	7.072	7.077	7.082	7.087	7.093	7.098	7.103	7.108	7.113
157	7.119	7.124	7.129	7.134	7.139	7.144	7.150	7.155	7.160	7.165
158	7.170	7.175	7.181	7.186	7.191	7.196	7.201	7.207	7.212	7.217
159	7.222	7.227	7.233	7.238	7.243	7.248	7.253	7.258	7.264	7.269
160	7.274	7.279	7.284	7.290	7.295	7.300	7.305	7.310	7.316	7.321
161	7.326	7.331	7.336	7.342	7.347	7.352	7.357	7.363	7.368	7.373
162	7.378	7.383	7.389	7.394	7.399	7.404	7.409	7.415	7.420	7.425
163	7.430	7.436	7.441	7.446	7.451	7.456	7.462	7.467	7.472	7.477
164	7.483	7.488	7.493	7.498	7.503	7.509	7.514	7.519	7.524	7.530
165	7.535	7.540	7.545	7.551	7.556	7.561	7.566	7.572	7.577	7.582
166	7.587	7.593	7.598	7.603	7.608	7.614	7.619	7.624	7.629	7.635
167	7.640	7.645	7.650	7.656	7.661	7.666	7.671	7.677	7.682	7.687
168	7.692	7.698	7.703	7.708	7.713	7.719	7.724	7.729	7.734	7.740
169	7.745	7.750	7.756	7.761	7.766	7.771	7.777	7.782	7.787	7.792
170	7.798	7.803	7.808	7.814	7.819	7.824	7.829	7.835	7.840	7.845
171	7.851	7.856	7.861	7.866	7.872	7.877	7.882	7.888	7.893	7.898
172	7.903	7.909	7.914	7.919	7.925	7.930	7.935	7.941	7.946	7.951
173	7.956	7.962	7.967	7.972	7.978	7.983	7.988	7.994	7.999	8.004
174	8.010	8.015	8.020	8.025	8.031	8.036	8.041	8.047	8.052	8.057
175	8.063	8.068	8.073	8.079	8.084	8.089	8.095	8.100	8.105	8.111
176	8.116	8.121	8.127	8.132	8.137	8.143	8.148	8.153	8.159	8.164
177	8.169	8.175	8.180	8.185	8.191	8.196	8.201	8.207	8.212	8.217
178	8.223	8.228	8.233	8.239	8.244	8.249	8.255	8.260	8.265	8.271
179	8.276	8.281	8.287	8.292	8.297	8.303	8.308	8.313	8.319	8.324
180	8.330	8.335	8.340	8.346	8.351	8.356	8.362	8.367	8.372	8.378
181	8.383	8.389	8.394	8.399	8.405	8.410	8.415	8.421	8.426	8.432
182	8.437	8.442	8.448	8.453	8.458	8.464	8.469	8.475	8.480	8.485
183	8.491	8.496	8.501	8.507	8.512	8.518	8.523	8.528	8.534	8.539
184	8.545	8.550	8.555	8.561	8.566	8.571	8.577	8.582	8.588	8.593
185	8.598	8.604	8.609	8.615	8.620	8.625	8.631	8.636	8.642	8.647
186	8.653	8.658	8.663	8.669	8.674	8.680	8.685	8.690	8.696	8.701
187	8.707	8.712	8.717	8.723	8.728	8.734	8.739	8.745	8.750	8.755
188	8.761	8.766	8.772	8.777	8.782	8.788	8.793	8.799	8.804	8.810
189	8.815	8.820	8.826	8.831	8.837	8.842	8.848	8.853	8.859	8.864
190	8.869	8.875	8.880	8.886	8.891	8.897	8.902	8.908	8.913	8.918
191	8.924	8.929	8.935	8.940	8.946	8.951	8.957	8.962	8.967	8.973
192	8.978	8.984	8.989	8.995	9.000	9.006	9.011	9.017	9.022	9.027
193	9.033	9.038	9.044	9.049	9.055	9.060	9.066	9.071	9.077	9.082
194	9.088	9.093	9.099	9.104	9.110	9.115	9.120	9.126	9.131	9.137
195	9.142	9.148	9.153	9.159	9.164	9.170	9.175	9.181	9.186	9.192
196	9.197	9.203	9.208	9.214	9.219	9.225	9.230	9.236	9.241	9.247
197	9.252	9.258	9.263	9.269	9.274	9.280	9.285	9.291	9.296	9.302
198	9.307	9.313	9.318	9.324	9.329	9.335	9.340	9.346	9.351	9.357
199	9.362	9.368	9.373	9.379	9.384	9.390	9.395	9.401	9.406	9.412
200	9.417	9.423	9.428	9.434	9.439	9.445	9.450	9.456	9.462	9.467

APPENDIX E

SERIES 'A' - EXPERIMENTAL RESULTS

E1 THERMAL CONDUCTIVITY DETERMINATION

E1.1 POSITIONING OF SPECIMENS

During the experimental runs using clear perspex plates, the clear perspex plate marked 'CA' was held between aluminium plates 11a and 13a in Figure 2-5. The perspex plate labelled 'CB' was held between the aluminium plates 11b and 13b. Similarly, during white perspex experimental runs, the perspex plate marked 'WA' was held between the aluminium plates 11a and 13a, while that marked 'WB' was held between the plates 11b and 13b.

The thicknesses of the perspex plates were:

(i) Clear perspex:

plate 'CA' = 5.94mm

plate 'CB' = 5.74mm

(ii) White perspex:

plate 'WA' = 6.21mm

plate 'WB' = 6.29mm

E1.2 THERMAL CONDUCTIVITIES OF THE SPECIMENS

Table E1 shows the thermal conductivities of the clear and white perspex specimens.

E2 SPECIMENS WITH HOLES DRILLED

The clear perspex plates 'CA' and 'CB' had 30.5mm holes drilled (in a square pitch pattern). The resulting temperature drops across the specimens were of interest (since in Table E1, the temperature drops across the specimens were small). Table E2 shows the resulting temperature drops.

TABLE E1

Thermal Conductivities (Clear and White Perspex)

Run	Specimen Plate Number	Temperature of Specimen Surface Hot °C	Temperature of Specimen Surface Cold °C	Temperature Drop Across Specimen °C	Mean Specimen Temperature °C	Thermal Conductivity W/M°C
1	CA	38.29	37.29	1	37.79	0.179
	CB	38.26	37.25	1.01	37.76	0.172
2	CA	38.89	37.83	1.06	38.36	0.169
	CB	38.82	37.71	1.11	38.27	0.155
3	CA	42.93	41.33	1.6	42.13	0.181
	CB	42.84	41.17	1.67	42.01	0.163
4	CA	45.24	43.29	1.95	44.27	0.172
	CB	45.08	43.06	2.02	44.07	0.16
5	CA	45.47	43.43	2.04	44.45	0.165
	CB	45.25	43.24	2.01	44.25	0.161
6	CA	45.81	43.76	2.05	44.79	0.164
	CB	45.52	43.57	1.95	44.55	0.167
7	CA	45.14	43.19	1.95	44.17	0.171
	CB	44.97	42.94	2.03	43.96	0.159
8	CA	45.02	43.06	1.96	44.04	0.172
	CB	44.83	42.81	2.02	43.82	0.162
9	WA	39.26	37.40	1.86	38.33	0.188
	WB	39.13	37.19	1.94	38.16	0.184
10	WA	34.97	33.35	1.62	34.16	0.217
	WB	34.97	33.55	1.62	34.16	0.22
11	WA	34.56	33.10	1.46	33.83	0.244
	WB	34.53	33.12	1.41	33.83	0.251

TABLE E2

Temperature Drops Across Clear Perspex Plates With 30.5mm Holes

Run	Specimen Plate Number	Temperature of Specimen Surface Hot ^{o}C	Temperature of Specimen Surface Cold ^{o}C	Temperature Drop Across Specimen ^{o}C	Electrical Power Into Specimen (W)
1	CA	50.83	48.6	2.23	2.285
	CB	50.48	47.8	2.68	2.285
2	CA	50.88	48.7	2.18	2.285
	CB	50.64	48.07	2.57	2.285
3	CA	50.98	48.86	2.12	2.285
	CB	50.74	48.14	2.6	2.285
4	CA	51.72	49.6	2.12	2.284
	CB	51.28	48.79	2.49	2.284
5	CA	51.58	49.56	2.02	2.284
	CB	51.38	48.6	2.73	2.284
6	CA	51.58	49.58	2.0	2.285
	CB	51.35	48.64	2.71	2.285

APPENDIX F

SERIES 'B' - RAW EXPERIMENTAL DATA AND RESULTS

LIST OF TABLES

F1 CONDUCTIVITY (CONDUCTANCE) SAMPLE CALCULATION

The thermal conductivity (or conductance for specimens with holes in them) was calculated using equation 1-1.

$$q = kA\frac{dT}{dx} \qquad (1\text{-}1)$$

Consider for example, run 1. The measured millivolts for the cold aluminium plate 11a (thermocouple wires 1 to 9) were: 1.977, 1.979, 1.977, 1.980, 1.980, 1.979, 1.978, 1.979 and 1.979.

Hence, the mean = 1.979mV with a standard deviation of 0.001. From the thermocouple equation D-1, this corresponds to a temperature of 49.348^{o}C.

For the hot aluminium plate 13a (thermocouple wires 10 to 18), the millivolts measured were: 2.048, 2.049, 2.047, 2.049, 2.049, 2.048, 2.050, 2.051 and 2.049.

The mean = 2.049mV with a standard deviation of 0.001. The temperature = 51.031^{o}C.

Since perspex plate number 1 was used in this run,

$dx = 5.69 \times 10^{-3}$ metres

The area perpendicular to the direction of heat flow 'A' is 0.04m^2 (Figure 2-7).

The heat input is the product of the current and the voltage.

$$Q = \left(\frac{0.5187 + 0.5189}{2}\right) \text{ amps} \times \left(\frac{35.42 + 35.43}{2}\right) \text{ volts}$$

$$= 18.378 \text{ watts}$$

The power into the metered section of the guarded hot plate is 18.378/4 watts. Since the two specimens exist, the power into the central section of each specimen = 18.378/4/2.

$q = 2.297$ watts

Substituting the above values into equation 1-1,

$$2.297 = \frac{k \times 0.04 \times (51.031 - 49.348)}{5.69 \times 10^{3}}$$

Hence,

$\underline{k = 0.194 \text{ W/M}^{\circ}\text{C}}$

The above calculation of the thermal conductivity of 5.6mm perspex was for the specimen held between aluminium plates 11a and 13a. In the computer program used to evaluate the thermal conductivities and conductances, it is designated the 'top specimen'. The 'bottom specimen (plate)' refers to the specimen held between aluminium plates 11b and 13b. The millivolts of the bottom plate are those indicated by thermocouple wires numbered 19 to 27 and 28 to 32. Although thermocouple readings of wires numbered 33 to 36 were taken, they are not shown in the raw data presented (recall these thermocouple wires used 39 gauge constantan instead of 36 gauge due to the lack of thermocouple wire in New Zealand).

For specimens with holes in them, the above procedure was repeated, but the evaluated k was termed 'the thermal conductance' - in the computer printout presented below, they were still called thermal conductivities rather than thermal conductances.

F2 COMPUTER PRINTOUTS OF RAW EXPERIMENTAL DATA AND CALCULATED RESULTS

Tables F3 to F14 present the raw experimental data and the calculated results for Series 'B' experiments (runs 1 to 738).

Notation:

K	run number counter
XBAR	mean of the millivolt readings (mV)
STD	standard deviation of the millivolt readings
TEMP	the temperature corresponding to XBAR millivolts (^{o}C)
AMPS1 (VOLTS1)	Current (voltage) indicated by multimeter before millivolts were recorded
AMPS2 (VOLTS2)	Current (voltage) after all the millivolt readings had been taken
DTETOP	temperature drop across top specimen (^{o}C)
DTEBOT	temperature drop across bottom specimen (^{o}C)
THITOP	thickness of top specimen (metres)
THIBOT	thickness of bottom specimen (metres)
WATTAGE	heat input into the metered area of each specimen (watts)
CODCTO	conductivity (conductance) of top specimen (W/M^{o}C)
CODCBO	conductivity (conductance) of bottom specimen (W/M^{o}C)
AVTTOP	mean (average) temperature of top specimen (^{o}C)
AVTBOT	mean temperature of bottom specimen

F3 CALCULATIONS OF RAYLEIGH AND GRASHOF NUMBERS

$$Gr = \frac{\beta g \rho^2 (T_h - T_c) L^3}{\mu^2} \qquad \text{(F-1)}$$

$$Pr = \frac{C_p \mu}{k} \qquad \text{(F-2)}$$

$$Ra = Gr \times Pr \qquad \text{(F-3)}$$

The fluid (air) properties are obtained from references 146, 167 and 168. They are evaluated at the mean temperature. The calculated Rayleigh number is based on the height of air cavity (thickness of specimen).

For experimental runs used in the numerical simulations, the Rayleigh and Grashof numbers computed are presented in Table F1.

F4 MEAN THERMAL CONDUCTIVITIES OF PERSPEX

The mean thermal conductivities of 5.6mm and 11mm thick perspex plates are summarised in Table 4-2. In runs 1 to 158 (range covered by Table 4-2), the perspex plates 1 to 8 had their thermal conductivities determined for various positionings of the perspex plates (specimens) in the guarded hot plate. In Table F2, the means of various configurations are tabulated. For example, the (mean of the mean) thermal conductivity of perspex plate 1 is (0.1934 + 0.1946)/2 = 0.1940 W/M$^{\circ}$C with a standard deviation of 0.0008 W/M$^{\circ}$C. The error in the determination of the thermal conductivity of plate 1 = standard deviation/mean thermal conductivity.

$$= \frac{0.0008}{0.194} \times 100$$

$$= 0.41\%$$

TABLE F1

Rayleigh and Grashof Numbers

Run	T_h	T_c	Mean Temperature ^oC	^oK	Viscosity $\times 10^{-6}$ Ns/m^2	Density kg/m^3	Gr	Pr	Ra
159	52.32	48.68	50.5	323.5	19.65	1.0915	465.3	0.7	325.7
172	36.48	35.67	36.08	309.08	19	1.1389	126.2	0.7	88.3
186	61.76	56.25	58.99	331.99	20.06	1.0634	625.1	0.7	437.6
201	51.99	48.25	50.11	323.11	19.64	1.0928	480.3	0.7	336.2
315	50.89	48.73	49.82	322.82	19.62	1.0938	37	0.7	35.9
331	36.36	35.82	36.08	309.08	19	1.1389	11	0.7	7.8
341	61.78	58.37	60.08	333.08	20.11	1.06	50.7	0.7	35.5
549	47.67	43.41	45.54	318.54	19.42	1.1084	583.9	0.7	408.7
556	56.27	49.64	52.95	325.95	19.77	1.0833	818.5	0.7	573.0
568	66.2	56.1	61.15	334.15	20.16	1.0566	1112.8	0.7	779
576	76.68	63.25	69.97	342.97	20.58	1.0294	1313	0.7	919
605	77.07	60.94	69.00	342	20.53	1.0323	2052.3	0.7	1436.6
611	96.09	72.43	84.26	357.26	21.23	0.9882	2469.6	0.7	1728.7
617	112.57	82.26	97.42	370.42	21.82	0.9539	2691.5	0.7	1884
624	162.77	111.23	137.01	410.01	23.57	0.8608	2885.7	0.7	2020
629	86.21	66.51	76.35	349.35	20.87	1.0105	2275	0.7	1593
679	47.34	42.59	44.96	317.96	19.39	1.1105	656.7	0.7	459.7
686	55.94	48.42	52.17	325.17	19.73	1.0859	938.9	0.7	657.2
692	66.76	55.63	61.19	334.19	20.16	1.0565	1226	0.7	858
698	78.36	63.14	70.74	343.74	20.61	1.0271	1474	0.7	1032

TABLE F2

The (Mean of the Mean) Thermal Conductivities of 5.6mm and 11mm Thick Perspex Plates

Plate	Thermal Conductivity in W/M^{o}C		
	Mean	Std Deviation	Error%
1	0.1940	.0008	0.41
2	0.1795	.0025	1.39
3	0.1911	.0077	4.03
4	0.1795	.0042	2.34
5	0.2003	.0071	3.54
6	0.2194	.0001	0.05
7	0.2088	.0049	2.35
8	0.2074	.0055	2.65

TABLE F3

Raw Experimental Data

Thermocouple Wires Numbers 1 to 9

MILLIVOLTS READ IN FOR POSITIONS 1 TO 9 ARE

1	1.977	1.979	1.977	1.980	1.980	1.979	1.978	1.979	1.979
2	1.979	1.983	1.980	1.983	1.984	1.983	1.982	1.983	1.983
3	1.981	1.983	1.981	1.984	1.985	1.984	1.984	1.985	1.984
4	1.984	1.986	1.984	1.986	1.987	1.986	1.985	1.987	1.986
5	1.984	1.987	1.984	1.987	1.988	1.987	1.986	1.988	1.987
6	1.986	1.987	1.985	1.988	1.989	1.988	1.987	1.988	1.988
7	1.986	1.988	1.965	1.988	1.989	1.988	1.987	1.989	1.989
8	1.989	1.992	1.989	1.992	1.993	1.993	1.991	1.993	1.993
9	1.988	1.990	1.987	1.989	1.990	1.989	1.989	1.989	1.989
10	1.989	1.990	1.987	1.989	1.990	1.989	1.988	1.990	1.988
11	1.989	1.990	1.989	1.991	1.992	1.990	1.989	1.991	1.990
12	1.989	1.991	1.988	1.991	1.993	1.991	1.990	1.991	1.990
13	1.989	1.990	1.988	1.992	1.993	1.991	1.990	1.992	1.992
14	1.988	1.990	1.988	1.991	1.993	1.991	1.990	1.991	1.991
15	1.988	1.989	1.988	1.990	1.991	1.990	1.989	1.991	1.990
16	1.988	1.989	1.987	1.989	1.992	1.991	1.989	1.991	1.990
17	1.988	1.989	1.988	1.990	1.991	1.990	1.989	1.991	1.991
18	1.989	1.991	1.989	1.991	1.992	1.992	1.989	1.991	1.990
19	1.989	1.991	1.989	1.991	1.992	1.991	1.989	1.991	1.991
20	1.988	1.990	1.987	1.990	1.990	1.990	1.988	1.990	1.990
21	1.988	1.989	1.988	1.990	1.992	1.990	1.989	1.991	1.990
22	1.989	1.993	1.990	1.991	1.993	1.992	1.990	1.993	1.991
23	1.992	1.994	1.992	1.993	1.994	1.994	1.991	1.993	1.993
24	1.992	1.993	1.992	1.994	1.995	1.994	1.993	1.994	1.994
25	1.991	1.993	1.991	1.993	1.995	1.994	1.993	1.994	1.994
26	1.991	1.993	1.991	1.993	1.994	1.993	1.992	1.994	1.993
27	1.991	1.994	1.991	1.994	1.995	1.993	1.991	1.994	1.993
28	1.991	1.993	1.991	1.993	1.994	1.993	1.991	1.993	1.993
29	1.462	1.463	1.463	1.463	1.463	1.464	1.464	1.464	1.464
30	1.459	1.459	1.459	1.460	1.460	1.460	1.460	1.460	1.460
31	1.451	1.452	1.452	1.453	1.454	1.454	1.454	1.455	1.455
32	1.450	1.448	1.448	1.448	1.448	1.448	1.448	1.448	1.449
33	1.448	1.448	1.447	1.448	1.448	1.448	1.448	1.448	1.448
34	1.434	1.436	1.435	1.436	1.436	1.436	1.436	1.436	1.436
35	1.436	1.438	1.438	1.438	1.438	1.438	1.438	1.438	1.438
36	1.438	1.438	1.438	1.438	1.438	1.438	1.438	1.438	1.438
37	1.438	1.439	1.439	1.439	1.439	1.439	1.439	1.439	1.439
38	1.439	1.439	1.439	1.440	1.440	1.440	1.440	1.440	1.440
39	1.440	1.441	1.441	1.441	1.441	1.441	1.441	1.441	1.441
40	1.440	1.441	1.441	1.441	1.441	1.441	1.441	1.441	1.441
41	1.441	1.441	1.441	1.441	1.441	1.441	1.441	1.441	1.441
42	1.442	1.443	1.443	1.443	1.443	1.443	1.443	1.443	1.443
43	2.388	2.389	2.386	2.389	2.390	2.389	2.388	2.389	2.388
44	2.386	2.388	2.384	2.388	2.389	2.388	2.387	2.389	2.388
45	2.386	2.388	2.385	2.388	2.389	2.389	2.387	2.388	2.388
46	2.386	2.388	2.385	2.388	2.389	2.388	2.387	2.389	2.388
47	2.386	2.388	2.384	2.389	2.389	2.388	2.387	2.389	2.389
48	2.386	2.389	2.384	2.389	2.389	2.389	2.387	2.389	2.387
49	2.385	2.386	2.383	2.388	2.389	2.389	2.385	2.386	2.387
50	2.391	2.393	2.390	2.394	2.395	2.394	2.392	2.394	2.394
51	2.389	2.391	2.389	2.393	2.394	2.393	2.391	2.393	2.391
52	2.389	2.392	2.389	2.391	2.393	2.393	2.390	2.393	2.391
53	2.389	2.390	2.387	2.391	2.391	2.390	2.389	2.391	2.390
54	2.387	2.389	2.386	2.389	2.390	2.389	2.388	2.389	2.389
55	2.387	2.389	2.387	2.389	2.390	2.389	2.389	2.389	2.389
56	2.029	2.030	2.028	2.030	2.031	2.030	2.029	2.030	2.030
57	2.024	2.026	2.024	2.026	2.027	2.026	2.025	2.027	2.025
58	2.020	2.021	2.019	2.022	2.023	2.023	2.020	2.022	2.020
59	2.017	2.019	2.017	2.019	2.020	2.020	2.019	2.020	2.019
60	2.016	2.017	2.015	2.018	2.018	2.018	2.017	2.018	2.017
61	2.038	2.039	2.037	2.040	2.040	2.039	2.039	2.040	2.039
62	2.032	2.034	2.032	2.035	2.036	2.034	2.033	2.034	2.034
63	2.029	2.030	2.029	2.031	2.032	2.031	2.030	2.031	2.030
64	2.028	2.029	2.028	2.029	2.031	2.029	2.029	2.030	2.029
65	2.027	2.029	2.026	2.029	2.029	2.029	2.028	2.029	2.029
66	2.023	2.023	2.022	2.025	2.026	2.025	2.024	2.024	2.024
67	2.023	2.023	2.021	2.023	2.025	2.024	2.023	2.024	2.024
68	2.021	2.022	2.021	2.023	2.024	2.023	2.023	2.024	2.022
69	2.018	2.019	2.017	2.018	2.019	2.018	2.017	2.018	2.017
70	2.015	2.017	2.014	2.017	2.018	2.017	2.016	2.017	2.016
71	2.013	2.014	2.013	2.015	2.016	2.015	2.014	2.015	2.014
72	2.011	2.013	2.011	2.014	2.014	2.013	2.013	2.014	2.013

TABLE F3 (continued)

73	2.010	2.012	2.011	2.013	2.014	2.013	2.013	2.013	2.013
74	2.009	2.010	2.009	2.010	2.011	2.010	2.010	2.010	2.010
75	2.006	2.007	2.004	2.007	2.008	2.006	2.005	2.006	2.006
76	2.006	2.007	2.004	2.008	2.008	2.007	2.007	2.007	2.007
77	2.006	2.007	2.005	2.008	2.008	2.007	2.006	2.007	2.006
78	2.000	2.000	1.998	2.001	2.001	2.001	2.000	2.000	2.000
79	2.000	2.002	2.001	2.003	2.004	2.003	2.002	2.003	2.002
80	2.001	2.003	2.001	2.004	2.004	2.003	2.002	2.002	2.002
81	1.959	1.961	1.959	1.961	1.961	1.961	1.959	1.960	1.959
82	1.945	1.947	1.945	1.948	1.948	1.946	1.946	1.948	1.947
83	1.952	1.954	1.952	1.955	1.956	1.954	1.952	1.954	1.953
84	1.950	1.952	1.949	1.951	1.952	1.951	1.950	1.951	1.950
85	1.945	1.947	1.945	1.947	1.948	1.946	1.945	1.947	1.945
86	1.944	1.946	1.943	1.946	1.948	1.946	1.945	1.946	1.945
87	1.944	1.946	1.943	1.947	1.948	1.946	1.944	1.946	1.946
88	1.962	1.967	1.964	1.966	1.968	1.966	1.964	1.967	1.965
89	1.957	1.959	1.958	1.959	1.960	1.959	1.958	1.959	1.958
90	1.950	1.952	1.950	1.952	1.953	1.952	1.951	1.952	1.952
91	1.949	1.951	1.949	1.951	1.952	1.951	1.949	1.951	1.950
92	1.949	1.950	1.949	1.950	1.951	1.950	1.949	1.950	1.950
93	1.953	1.955	1.952	1.955	1.956	1.955	1.953	1.955	1.955
94	1.430	1.431	1.430	1.430	1.430	1.430	1.430	1.430	1.430
95	1.434	1.435	1.434	1.436	1.436	1.436	1.435	1.435	1.435
96	1.433	1.434	1.434	1.434	1.435	1.435	1.435	1.435	1.435
97	1.440	1.440	1.440	1.440	1.440	1.440	1.440	1.440	1.440
98	1.439	1.440	1.440	1.440	1.440	1.440	1.440	1.440	1.440
99	1.438	1.439	1.439	1.439	1.439	1.440	1.440	1.440	1.440
100	1.438	1.439	1.439	1.439	1.439	1.439	1.439	1.439	1.439
101	1.430	1.431	1.431	1.431	1.431	1.431	1.430	1.431	1.431
102	1.435	1.437	1.437	1.437	1.437	1.437	1.437	1.437	1.437
103	1.435	1.438	1.438	1.438	1.438	1.438	1.438	1.438	1.438
104	1.435	1.437	1.437	1.438	1.438	1.438	1.438	1.438	1.438
105	1.434	1.437	1.437	1.437	1.438	1.438	1.438	1.438	1.438
106	1.434	1.434	1.434	1.435	1.435	1.435	1.435	1.435	1.435
107	2.327	2.329	2.327	2.329	2.330	2.329	2.327	2.329	2.329
108	2.321	2.325	2.321	2.324	2.326	2.324	2.321	2.324	2.323
109	2.316	2.319	2.314	2.319	2.320	2.319	2.316	2.319	2.316
110	2.330	2.332	2.330	2.332	2.334	2.333	2.330	2.332	2.331
111	2.322	2.327	2.321	2.325	2.328	2.327	2.323	2.326	2.323
112	2.317	2.320	2.316	2.319	2.320	2.320	2.318	2.319	2.319
113	2.311	2.314	2.310	2.313	2.316	2.314	2.311	2.314	2.312
114	2.308	2.309	2.307	2.309	2.310	2.309	2.308	2.309	2.309
115	2.308	2.307	2.302	2.306	2.309	2.307	2.303	2.307	2.304
116	2.300	2.303	2.300	2.302	2.304	2.303	2.300	2.303	2.302
117	2.298	2.300	2.299	2.300	2.301	2.300	2.299	2.300	2.299
118	2.291	2.294	2.290	2.293	2.295	2.294	2.291	2.294	2.293
119	2.290	2.293	2.289	2.292	2.294	2.293	2.290	2.292	2.291
120	1.993	1.995	1.992	1.995	1.996	1.996	1.993	1.995	1.994
121	1.989	1.991	1.990	1.991	1.992	1.991	1.990	1.991	1.991
122	1.984	1.987	1.983	1.988	1.988	1.987	1.985	1.988	1.986
123	1.980	1.981	1.980	1.981	1.981	1.981	1.981	1.981	1.980
124	1.974	1.976	1.973	1.976	1.977	1.977	1.974	1.976	1.975
125	1.971	1.972	1.970	1.972	1.973	1.972	1.971	1.972	1.971
126	1.969	1.970	1.969	1.970	1.971	1.970	1.970	1.970	1.970
127	1.970	1.971	1.969	1.971	1.971	1.971	1.970	1.971	1.971
128	1.990	1.991	1.989	1.991	1.991	1.991	1.990	1.991	1.990
129	1.988	1.989	1.987	1.989	1.990	1.989	1.989	1.989	1.989
130	1.983	1.987	1.983	1.987	1.988	1.987	1.986	1.987	1.986
131	1.980	1.981	1.980	1.981	1.982	1.981	1.980	1.981	1.981
132	1.974	1.975	1.972	1.976	1.977	1.976	1.973	1.976	1.975
133	1.977	1.978	1.975	1.979	1.979	1.978	1.978	1.979	1.978
134	1.973	1.974	1.971	1.975	1.977	1.974	1.974	1.975	1.974
135	1.970	1.971	1.970	1.972	1.972	1.972	1.971	1.972	1.971
136	1.977	1.979	1.975	1.979	1.979	1.979	1.978	1.979	1.976
137	1.971	1.973	1.970	1.973	1.974	1.973	1.971	1.973	1.972
138	1.955	1.958	1.954	1.958	1.959	1.959	1.958	1.959	1.959
139	1.978	1.979	1.977	1.979	1.980	1.979	1.979	1.979	1.979
140	1.974	1.976	1.973	1.977	1.978	1.976	1.976	1.977	1.975
141	1.969	1.970	1.969	1.970	1.970	1.970	1.970	1.970	1.970
142	1.964	1.965	1.963	1.967	1.968	1.966	1.965	1.967	1.965
143	1.959	1.960	1.959	1.960	1.961	1.960	1.960	1.961	1.960
144	1.955	1.956	1.953	1.958	1.958	1.957	1.955	1.958	1.957
145	1.953	1.954	1.952	1.955	1.957	1.955	1.955	1.956	1.955
146	1.954	1.957	1.954	1.956	1.958	1.957	1.954	1.957	1.956
147	1.951	1.954	1.952	1.953	1.957	1.955	1.953	1.955	1.953
148	1.948	1.949	1.948	1.949	1.950	1.949	1.949	1.950	1.950
149	1.947	1.949	1.948	1.949	1.950	1.950	1.949	1.950	1.950

TABLE F3 (continued)

150	1.945	1.949	1.946	1.948	1.949	1.948	1.947	1.948	1.949
151	1.945	1.947	1.944	1.947	1.949	1.948	1.946	1.948	1.948
152	1.942	1.945	1.944	1.945	1.947	1.947	1.945	1.947	1.947
153	1.941	1.944	1.942	1.945	1.946	1.945	1.943	1.946	1.945
154	1.940	1.942	1.941	1.942	1.944	1.942	1.941	1.943	1.942
155	1.941	1.943	1.941	1.942	1.944	1.944	1.942	1.943	1.943
156	1.941	1.942	1.941	1.942	1.943	1.942	1.941	1.943	1.942
157	1.955	1.958	1.956	1.958	1.959	1.958	1.957	1.956	1.958
158	1.951	1.953	1.951	1.953	1.955	1.954	1.952	1.953	1.953
159	1.950	1.952	1.949	1.951	1.952	1.951	1.949	1.951	1.950
160	1.947	1.948	1.946	1.948	1.949	1.948	1.947	1.946	1.948
161	1.942	1.944	1.942	1.943	1.944	1.943	1.942	1.943	1.943
162	1.939	1.939	1.937	1.939	1.940	1.939	1.938	1.939	1.939
163	1.937	1.939	1.936	1.938	1.939	1.938	1.936	1.939	1.938
164	1.933	1.934	1.932	1.934	1.936	1.934	1.931	1.934	1.933
165	1.930	1.931	1.930	1.931	1.931	1.931	1.930	1.931	1.930
166	1.925	1.927	1.924	1.926	1.928	1.925	1.924	1.926	1.925
167	1.924	1.925	1.922	1.926	1.927	1.925	1.923	1.924	1.923
168	1.920	1.921	1.919	1.921	1.921	1.921	1.919	1.921	1.920
169	1.920	1.921	1.919	1.920	1.921	1.920	1.920	1.921	1.920
170	1.922	1.924	1.921	1.923	1.925	1.923	1.921	1.923	1.922
171	1.922	1.924	1.921	1.924	1.924	1.924	1.922	1.923	1.923
172	1.416	1.417	1.418	1.417	1.418	1.418	1.417	1.417	1.417
173	1.413	1.414	1.413	1.413	1.414	1.413	1.414	1.414	1.414
174	1.410	1.410	1.410	1.410	1.410	1.410	1.410	1.410	1.410
175	1.409	1.409	1.409	1.409	1.409	1.409	1.409	1.409	1.409
176	1.408	1.408	1.408	1.408	1.409	1.409	1.409	1.409	1.406
177	1.406	1.407	1.407	1.407	1.407	1.407	1.407	1.407	1.407
178	1.406	1.407	1.407	1.407	1.407	1.407	1.407	1.407	1.407
179	1.407	1.408	1.406	1.406	1.407	1.407	1.407	1.407	1.407
180	1.406	1.407	1.407	1.407	1.407	1.407	1.407	1.407	1.407
181	1.406	1.409	1.408	1.408	1.408	1.408	1.408	1.408	1.408
182	1.407	1.407	1.408	1.408	1.408	1.408	1.408	1.408	1.408
183	1.407	1.408	1.408	1.408	1.408	1.408	1.408	1.408	1.408
184	1.403	1.408	1.408	1.408	1.408	1.408	1.408	1.408	1.408
185	2.261	2.263	2.259	2.261	2.262	2.261	2.259	2.261	2.261
186	2.267	2.269	2.264	2.268	2.269	2.268	2.266	2.269	2.268
187	2.265	2.268	2.263	2.268	2.269	2.267	2.264	2.268	2.266
188	2.288	2.289	2.285	2.288	2.289	2.288	2.287	2.289	2.288
189	2.271	2.274	2.270	2.273	2.274	2.273	2.270	2.273	2.272
190	2.309	2.311	2.308	2.310	2.312	2.311	2.308	2.310	2.310
191	2.300	2.302	2.299	2.302	2.303	2.301	2.299	2.301	2.300
192	2.293	2.295	2.291	2.294	2.297	2.294	2.292	2.294	2.293
193	2.276	2.279	2.274	2.278	2.279	2.277	2.274	2.278	2.276
194	2.271	2.273	2.270	2.271	2.273	2.272	2.270	2.272	2.271
195	2.268	2.269	2.265	2.269	2.270	2.269	2.267	2.269	2.268
196	2.265	2.268	2.263	2.268	2.268	2.268	2.264	2.268	2.267
197	2.267	2.269	2.264	2.268	2.269	2.268	2.265	2.268	2.268
198	1.940	1.942	1.940	1.941	1.943	1.941	1.940	1.942	1.942
199	1.938	1.940	1.938	1.939	1.940	1.939	1.938	1.939	1.939
200	1.934	1.938	1.934	1.937	1.938	1.937	1.934	1.938	1.937
201	1.932	1.934	1.931	1.932	1.934	1.934	1.931	1.934	1.933
202	1.930	1.931	1.930	1.931	1.932	1.931	1.930	1.932	1.931
203	1.928	1.930	1.928	1.929	1.930	1.930	1.929	1.930	1.929
204	1.929	1.929	1.927	1.929	1.930	1.929	1.929	1.929	1.929
205	1.927	1.928	1.926	1.928	1.929	1.929	1.927	1.929	1.929
206	1.926	1.928	1.925	1.927	1.928	1.928	1.925	1.928	1.928
207	1.924	1.926	1.923	1.925	1.927	1.925	1.923	1.925	1.925
208	1.923	1.926	1.923	1.924	1.926	1.925	1.923	1.925	1.924
209	1.922	1.925	1.922	1.923	1.925	1.924	1.922	1.924	1.924
210	1.919	1.920	1.919	1.920	1.920	1.920	1.919	1.920	1.920
211	1.925	1.927	1.924	1.927	1.928	1.926	1.925	1.927	1.927
212	1.928	1.929	1.926	1.929	1.929	1.928	1.928	1.928	1.928
213	1.927	1.928	1.925	1.928	1.928	1.927	1.926	1.927	1.927
214	1.927	1.928	1.925	1.928	1.928	1.927	1.926	1.927	1.927
215	1.927	1.928	1.925	1.928	1.928	1.927	1.926	1.927	1.928
216	1.948	1.949	1.947	1.948	1.949	1.948	1.948	1.948	1.946
217	1.942	1.944	1.942	1.943	1.944	1.943	1.942	1.944	1.943
218	1.940	1.941	1.939	1.941	1.942	1.941	1.940	1.941	1.940
219	1.937	1.939	1.938	1.939	1.939	1.939	1.938	1.939	1.939
220	1.933	1.935	1.932	1.934	1.936	1.934	1.932	1.934	1.934
221	1.932	1.933	1.932	1.934	1.934	1.934	1.932	1.933	1.933
222	1.930	1.931	1.930	1.931	1.932	1.930	1.930	1.931	1.931
223	1.928	1.929	1.927	1.928	1.929	1.928	1.927	1.929	1.928
224	1.921	1.923	1.921	1.922	1.923	1.921	1.922	1.923	1.922
225	1.922	1.923	1.921	1.922	1.923	1.922	1.921	1.922	1.922
226	1.920	1.921	1.919	1.920	1.921	1.920	1.920	1.921	1.920

TABLE F3 (continued)

227	1.922	1.923	1.921	1.922	1.923	1.922	1.921	1.922	1.922
228	1.922	1.923	1.921	1.922	1.923	1.923	1.922	1.922	1.922
229	1.918	1.919	1.916	1.918	1.919	1.916	1.917	1.916	1.918
230	1.919	1.919	1.918	1.919	1.920	1.919	1.919	1.919	1.919
231	1.918	1.920	1.918	1.920	1.920	1.919	1.919	1.919	1.919
232	1.922	1.923	1.922	1.923	1.924	1.923	1.922	1.923	1.923
233	1.923	1.924	1.923	1.924	1.925	1.924	1.923	1.925	1.924
234	1.924	1.926	1.923	1.926	1.927	1.926	1.924	1.925	1.925
235	1.923	1.925	1.922	1.924	1.925	1.924	1.924	1.924	1.924
236	1.925	1.925	1.924	1.927	1.927	1.926	1.924	1.927	1.927
237	1.919	1.920	1.918	1.920	1.920	1.920	1.919	1.920	1.919
238	1.914	1.915	1.912	1.916	1.917	1.916	1.914	1.916	1.915
239	1.911	1.912	1.910	1.912	1.913	1.912	1.911	1.912	1.911
240	1.910	1.911	1.909	1.911	1.911	1.910	1.910	1.910	1.910
241	1.918	1.919	1.917	1.919	1.919	1.918	1.918	1.916	1.918
242	1.918	1.919	1.917	1.919	1.920	1.919	1.918	1.919	1.918
243	1.917	1.918	1.917	1.919	1.920	1.919	1.918	1.919	1.918
244	1.918	1.919	1.917	1.919	1.919	1.918	1.917	1.919	1.918
245	1.918	1.919	1.918	1.919	1.920	1.919	1.918	1.919	1.919
246	1.919	1.919	1.917	1.919	1.920	1.920	1.919	1.919	1.919
247	1.918	1.919	1.917	1.919	1.920	1.919	1.919	1.919	1.919
248	1.919	1.920	1.918	1.920	1.920	1.920	1.919	1.919	1.919
249	1.919	1.920	1.918	1.920	1.920	1.920	1.919	1.920	1.919
250	1.407	1.409	1.407	1.407	1.407	1.408	1.408	1.408	1.408
251	1.407	1.408	1.408	1.408	1.408	1.408	1.408	1.408	1.408
252	1.407	1.408	1.407	1.407	1.407	1.407	1.407	1.407	1.407
253	1.407	1.407	1.406	1.406	1.407	1.407	1.407	1.407	1.407
254	1.405	1.406	1.405	1.407	1.407	1.407	1.407	1.407	1.407
255	1.404	1.404	1.403	1.404	1.404	1.404	1.404	1.404	1.404
256	1.404	1.404	1.403	1.404	1.404	1.404	1.404	1.404	1.404
257	1.403	1.404	1.403	1.403	1.403	1.403	1.403	1.403	1.403
258	1.403	1.404	1.403	1.403	1.403	1.403	1.403	1.403	1.403
259	1.401	1.402	1.401	1.401	1.402	1.402	1.401	1.401	1.401
260	1.401	1.402	1.402	1.402	1.402	1.402	1.402	1.402	1.402
261	1.401	1.402	1.402	1.402	1.402	1.402	1.402	1.402	1.402
262	1.401	1.402	1.402	1.402	1.402	1.402	1.402	1.402	1.402
263	2.260	2.262	2.260	2.262	2.263	2.262	2.261	2.262	2.261
264	2.262	2.264	2.260	2.263	2.265	2.263	2.262	2.263	2.262
265	2.267	2.269	2.264	2.268	2.269	2.266	2.267	2.268	2.268
266	2.267	2.269	2.266	2.269	2.270	2.269	2.267	2.269	2.268
267	2.268	2.270	2.267	2.270	2.270	2.269	2.268	2.269	2.268
268	2.269	2.270	2.268	2.270	2.271	2.270	2.268	2.270	2.269
269	2.269	2.270	2.267	2.270	2.271	2.270	2.268	2.269	2.269
270	2.270	2.271	2.269	2.271	2.272	2.270	2.270	2.271	2.270
271	2.270	2.272	2.269	2.271	2.272	2.271	2.270	2.271	2.270
272	2.270	2.272	2.269	2.272	2.273	2.271	2.270	2.271	2.270
273	2.270	2.273	2.269	2.272	2.273	2.272	2.270	2.271	2.270
274	2.269	2.271	2.268	2.270	2.272	2.270	2.269	2.270	2.269
275	2.269	2.270	2.268	2.270	2.271	2.270	2.269	2.270	2.269
276	1.956	1.958	1.955	1.958	1.959	1.956	1.956	1.958	1.957
277	1.954	1.957	1.954	1.957	1.957	1.957	1.954	1.955	1.955
278	1.953	1.956	1.953	1.956	1.957	1.956	1.954	1.956	1.954
279	1.952	1.953	1.951	1.953	1.954	1.952	1.953	1.953	1.952
280	1.950	1.952	1.950	1.952	1.952	1.952	1.951	1.952	1.952
281	1.950	1.950	1.949	1.950	1.951	1.950	1.949	1.950	1.950
282	1.948	1.949	1.948	1.949	1.950	1.949	1.949	1.949	1.949
283	1.942	1.944	1.941	1.943	1.944	1.943	1.942	1.943	1.943
284	1.943	1.944	1.942	1.944	1.945	1.944	1.943	1.944	1.943
285	1.943	1.944	1.942	1.943	1.944	1.943	1.942	1.943	1.942
286	1.943	1.946	1.944	1.947	1.947	1.946	1.945	1.946	1.945
287	1.945	1.948	1.944	1.948	1.948	1.948	1.946	1.947	1.947
288	1.946	1.948	1.945	1.948	1.948	1.948	1.947	1.947	1.947
289	1.932	1.933	1.931	1.933	1.933	1.932	1.931	1.932	1.932
290	1.932	1.935	1.931	1.934	1.935	1.934	1.933	1.934	1.933
291	1.932	1.933	1.931	1.933	1.934	1.932	1.932	1.933	1.932
292	1.931	1.932	1.930	1.933	1.933	1.932	1.932	1.932	1.932
293	1.953	1.954	1.952	1.955	1.956	1.954	1.953	1.954	1.954
294	1.951	1.952	1.950	1.953	1.954	1.952	1.952	1.953	1.952
295	1.948	1.949	1.947	1.949	1.950	1.949	1.948	1.949	1.949
296	1.944	1.946	1.943	1.947	1.946	1.946	1.944	1.945	1.944
297	1.941	1.942	1.940	1.942	1.942	1.942	1.941	1.942	1.941
298	1.932	1.932	1.930	1.933	1.933	1.932	1.931	1.932	1.931
299	1.931	1.933	1.930	1.933	1.933	1.931	1.931	1.932	1.931
300	1.930	1.931	1.929	1.931	1.931	1.930	1.930	1.931	1.930
301	1.930	1.931	1.929	1.931	1.931	1.930	1.930	1.930	1.930
302	1.921	1.923	1.921	1.922	1.924	1.922	1.921	1.922	1.922
303	1.921	1.923	1.921	1.923	1.924	1.923	1.921	1.922	1.922

TABLE F3 (continued)

304	1.920	1.920	1.919	1.920	1.920	1.920	1.919	1.920	1.919
305	1.919	1.920	1.919	1.920	1.920	1.920	1.919	1.920	1.920
306	1.920	1.920	1.919	1.920	1.920	1.920	1.919	1.920	1.920
307	1.911	1.913	1.911	1.912	1.913	1.913	1.911	1.912	1.912
308	1.911	1.913	1.911	1.912	1.913	1.912	1.911	1.912	1.912
309	1.911	1.913	1.911	1.913	1.914	1.913	1.912	1.913	1.911
310	1.912	1.914	1.912	1.914	1.916	1.914	1.913	1.914	1.913
311	1.913	1.916	1.913	1.917	1.918	1.917	1.915	1.917	1.915
312	1.914	1.917	1.914	1.917	1.918	1.917	1.914	1.917	1.915
313	1.914	1.917	1.914	1.917	1.918	1.915	1.914	1.915	1.915
314	1.914	1.917	1.913	1.915	1.917	1.915	1.913	1.914	1.914
315	1.953	1.954	1.952	1.954	1.955	1.953	1.953	1.953	1.953
316	1.953	1.957	1.953	1.957	1.957	1.956	1.954	1.956	1.955
317	1.957	1.959	1.957	1.958	1.959	1.958	1.957	1.958	1.958
318	1.957	1.959	1.957	1.959	1.959	1.959	1.958	1.958	1.958
319	1.958	1.959	1.957	1.959	1.959	1.959	1.958	1.958	1.956
320	1.959	1.960	1.958	1.960	1.960	1.959	1.959	1.959	1.959
321	1.959	1.960	1.959	1.960	1.961	1.960	1.959	1.960	1.959
322	1.960	1.961	1.960	1.961	1.962	1.961	1.960	1.961	1.961
323	1.960	1.962	1.960	1.962	1.963	1.961	1.960	1.961	1.961
324	1.961	1.962	1.960	1.961	1.962	1.961	1.960	1.961	1.960
325	1.961	1.962	1.960	1.961	1.962	1.961	1.961	1.961	1.961
326	1.965	1.966	1.963	1.966	1.967	1.966	1.964	1.965	1.964
327	1.966	1.968	1.964	1.968	1.968	1.968	1.967	1.968	1.968
328	1.424	1.424	1.424	1.424	1.424	1.424	1.424	1.424	1.424
329	1.424	1.424	1.424	1.424	1.424	1.424	1.424	1.424	1.424
330	1.422	1.423	1.423	1.423	1.424	1.424	1.424	1.424	1.424
331	1.423	1.423	1.423	1.423	1.423	1.423	1.423	1.423	1.423
332	1.423	1.423	1.423	1.423	1.423	1.424	1.424	1.424	1.424
333	1.423	1.423	1.423	1.423	1.424	1.424	1.424	1.424	1.424
334	1.423	1.423	1.423	1.423	1.424	1.424	1.424	1.424	1.424
335	1.422	1.422	1.422	1.422	1.422	1.423	1.423	1.422	1.422
336	1.423	1.423	1.423	1.423	1.423	1.423	1.423	1.423	1.423
337	1.422	1.423	1.423	1.423	1.423	1.423	1.423	1.423	1.423
338	1.423	1.423	1.422	1.422	1.422	1.422	1.422	1.422	1.422
339	1.422	1.424	1.422	1.423	1.424	1.424	1.423	1.424	1.424
340	1.423	1.424	1.423	1.423	1.423	1.423	1.423	1.423	1.423
341	2.358	2.359	2.356	2.359	2.360	2.359	2.357	2.358	2.358
342	2.349	2.351	2.349	2.351	2.352	2.350	2.349	2.350	2.349
343	2.344	2.348	2.342	2.346	2.348	2.346	2.343	2.346	2.344
344	2.337	2.339	2.335	2.339	2.339	2.339	2.337	2.339	2.338
345	2.333	2.337	2.332	2.335	2.338	2.334	2.334	2.335	2.334
346	2.331	2.333	2.330	2.332	2.333	2.331	2.330	2.332	2.331
347	2.330	2.331	2.329	2.331	2.331	2.330	2.329	2.330	2.330
348	2.323	2.327	2.321	2.326	2.327	2.325	2.323	2.325	2.323
349	2.324	2.327	2.322	2.327	2.328	2.327	2.324	2.325	2.323
350	2.323	2.328	2.322	2.326	2.328	2.325	2.324	2.325	2.324
351	2.324	2.327	2.322	2.328	2.328	2.327	2.323	2.325	2.324
352	2.325	2.328	2.324	2.328	2.329	2.327	2.324	2.327	2.326
353	2.328	2.329	2.326	2.329	2.330	2.329	2.328	2.329	2.328
354	1.981	1.982	1.981	1.982	1.983	1.982	1.961	1.982	1.982
355	1.979	1.980	1.979	1.980	1.981	1.980	1.979	1.980	1.980
356	1.978	1.979	1.978	1.979	1.980	1.979	1.979	1.979	1.979
357	1.975	1.978	1.975	1.978	1.978	1.977	1.976	1.977	1.975
358	1.973	1.975	1.972	1.975	1.976	1.974	1.972	1.974	1.974
359	1.970	1.972	1.970	1.972	1.972	1.972	1.970	1.971	1.971
360	1.970	1.971	1.970	1.971	1.972	1.971	1.970	1.971	1.970
361	1.969	1.969	1.967	1.969	1.969	1.969	1.968	1.969	1.968
362	1.969	1.970	1.968	1.970	1.970	1.969	1.969	1.969	1.969
363	1.969	1.970	1.968	1.970	1.970	1.969	1.968	1.969	1.969
364	1.964	1.966	1.963	1.967	1.967	1.967	1.963	1.964	1.964
365	1.964	1.968	1.964	1.967	1.968	1.967	1.966	1.967	1.967
366	1.964	1.967	1.964	1.967	1.969	1.968	1.965	1.967	1.967
367	1.945	1.948	1.944	1.947	1.948	1.947	1.944	1.946	1.946
368	1.946	1.949	1.947	1.949	1.949	1.948	1.947	1.949	1.948
369	1.949	1.950	1.949	1.950	1.950	1.949	1.949	1.949	1.949
370	1.949	1.950	1.949	1.950	1.951	1.950	1.950	1.950	1.950
371	1.949	1.951	1.950	1.951	1.951	1.951	1.949	1.950	1.950
372	1.951	1.953	1.951	1.952	1.953	1.953	1.951	1.952	1.952
373	1.951	1.954	1.952	1.953	1.954	1.954	1.952	1.953	1.952
374	1.952	1.954	1.951	1.953	1.954	1.953	1.952	1.953	1.952
375	1.951	1.953	1.951	1.953	1.953	1.953	1.951	1.951	1.952
376	1.950	1.952	1.950	1.951	1.952	1.951	1.950	1.950	1.950
377	1.950	1.952	1.950	1.951	1.952	1.952	1.950	1.951	1.951
378	1.951	1.952	1.950	1.951	1.952	1.951	1.950	1.951	1.951
379	1.951	1.953	1.951	1.952	1.953	1.952	1.951	1.952	1.952
380	1.979	1.979	1.978	1.979	1.980	1.979	1.978	1.979	1.979

TABLE F3 (continued)

381	1.975	1.978	1.975	1.978	1.979	1.978	1.975	1.977	1.977
382	1.971	1.974	1.971	1.973	1.974	1.972	1.971	1.973	1.972
383	1.970	1.971	1.970	1.970	1.971	1.970	1.969	1.970	1.970
384	1.969	1.970	1.968	1.969	1.970	1.969	1.968	1.969	1.969
385	1.964	1.967	1.963	1.964	1.967	1.964	1.963	1.964	1.964
386	1.962	1.964	1.962	1.964	1.965	1.963	1.962	1.963	1.963
387	1.962	1.964	1.962	1.963	1.964	1.963	1.961	1.962	1.962
388	1.961	1.962	1.961	1.962	1.962	1.961	1.960	1.962	1.961
389	1.960	1.961	1.960	1.960	1.961	1.960	1.959	1.960	1.960
390	1.957	1.958	1.954	1.957	1.958	1.957	1.953	1.956	1.955
391	1.957	1.958	1.958	1.958	1.959	1.958	1.954	1.957	1.957
392	1.957	1.958	1.955	1.958	1.958	1.957	1.954	1.957	1.956
393	1.958	1.959	1.957	1.959	1.959	1.959	1.958	1.959	1.958
394	1.959	1.960	1.959	1.960	1.961	1.960	1.959	1.960	1.960
395	1.960	1.961	1.960	1.961	1.962	1.961	1.960	1.961	1.961
396	1.962	1.964	1.961	1.963	1.964	1.963	1.962	1.962	1.962
397	1.962	1.963	1.961	1.962	1.963	1.962	1.961	1.962	1.962
398	1.964	1.967	1.963	1.966	1.968	1.966	1.964	1.967	1.964
399	1.967	1.969	1.967	1.969	1.969	1.968	1.967	1.968	1.968
400	1.968	1.969	1.968	1.969	1.970	1.969	1.967	1.969	1.969
401	1.969	1.970	1.969	1.970	1.970	1.970	1.969	1.969	1.969
402	1.969	1.971	1.969	1.970	1.971	1.970	1.969	1.970	1.970
403	1.971	1.972	1.970	1.971	1.972	1.971	1.970	1.971	1.970
404	1.971	1.972	1.970	1.972	1.972	1.971	1.970	1.971	1.971
405	1.970	1.971	1.969	1.970	1.971	1.970	1.969	1.970	1.970
406	2.321	2.323	2.321	2.323	2.324	2.322	2.320	2.322	2.321
407	2.323	2.328	2.323	2.327	2.328	2.326	2.323	2.326	2.323
408	2.324	2.329	2.323	2.328	2.329	2.326	2.324	2.328	2.326
409	2.328	2.330	2.328	2.329	2.330	2.329	2.328	2.329	2.328
410	2.329	2.331	2.328	2.330	2.331	2.330	2.328	2.330	2.329
411	2.329	2.331	2.329	2.330	2.332	2.330	2.329	2.330	2.330
412	2.329	2.331	2.329	2.330	2.332	2.330	2.329	2.330	2.330
413	2.329	2.331	2.329	2.330	2.331	2.330	2.329	2.330	2.329
414	2.330	2.332	2.330	2.332	2.333	2.332	2.330	2.331	2.331
415	2.331	2.333	2.330	2.332	2.334	2.332	2.331	2.332	2.331
416	2.331	2.334	2.331	2.333	2.337	2.334	2.331	2.333	2.332
417	2.332	2.337	2.332	2.334	2.338	2.336	2.332	2.336	2.334
418	2.333	2.338	2.332	2.337	2.338	2.338	2.333	2.336	2.335
419	1.435	1.435	1.434	1.434	1.434	1.434	1.434	1.434	1.434
420	1.432	1.433	1.432	1.433	1.433	1.432	1.433	1.433	1.432
421	1.431	1.431	1.431	1.431	1.431	1.431	1.431	1.431	1.431
422	1.430	1.430	1.430	1.430	1.430	1.430	1.430	1.430	1.430
423	1.429	1.429	1.429	1.429	1.429	1.429	1.429	1.429	1.429
424	1.427	1.427	1.426	1.426	1.427	1.426	1.427	1.426	1.426
425	1.425	1.426	1.424	1.425	1.427	1.425	1.425	1.425	1.425
426	1.424	1.426	1.424	1.426	1.426	1.426	1.425	1.425	1.425
427	1.423	1.423	1.423	1.423	1.423	1.423	1.423	1.423	1.423
428	1.421	1.421	1.421	1.421	1.421	1.421	1.421	1.421	1.421
429	1.422	1.422	1.421	1.421	1.421	1.421	1.421	1.421	1.421
430	1.422	1.422	1.422	1.421	1.421	1.421	1.421	1.421	1.421
431	1.421	1.421	1.421	1.421	1.421	1.421	1.421	1.421	1.421
432	1.968	1.969	1.968	1.969	1.970	1.969	1.967	1.968	1.967
433	1.968	1.970	1.968	1.969	1.970	1.969	1.967	1.969	1.969
434	1.968	1.969	1.968	1.969	1.969	1.969	1.967	1.968	1.968
435	1.968	1.969	1.968	1.969	1.969	1.969	1.968	1.969	1.968
436	1.967	1.969	1.967	1.968	1.969	1.969	1.965	1.968	1.967
437	1.966	1.968	1.964	1.967	1.968	1.967	1.963	1.965	1.965
438	1.960	1.961	1.960	1.960	1.961	1.960	1.959	1.960	1.960
439	1.960	1.961	1.960	1.961	1.961	1.961	1.959	1.960	1.960
440	1.960	1.961	1.960	1.961	1.962	1.961	1.960	1.961	1.960
441	1.960	1.961	1.960	1.961	1.962	1.961	1.960	1.960	1.960
442	1.960	1.962	1.960	1.961	1.963	1.961	1.960	1.961	1.961
443	1.961	1.962	1.961	1.961	1.963	1.962	1.961	1.961	1.961
444	1.961	1.962	1.961	1.961	1.963	1.962	1.960	1.961	1.961
445	1.948	1.949	1.948	1.949	1.949	1.949	1.948	1.949	1.949
446	1.950	1.952	1.950	1.952	1.953	1.952	1.950	1.951	1.951
447	1.953	1.956	1.953	1.955	1.957	1.956	1.953	1.955	1.954
448	1.958	1.959	1.958	1.959	1.960	1.959	1.958	1.959	1.959
449	1.959	1.960	1.959	1.960	1.961	1.960	1.959	1.960	1.960
450	1.961	1.963	1.961	1.962	1.964	1.962	1.961	1.962	1.962
451	1.963	1.965	1.962	1.964	1.966	1.964	1.962	1.963	1.964
452	1.964	1.966	1.963	1.966	1.967	1.965	1.963	1.964	1.964
453	1.967	1.969	1.967	1.968	1.969	1.968	1.966	1.968	1.968
454	1.969	1.970	1.969	1.970	1.970	1.970	1.969	1.969	1.969
455	1.969	1.970	1.969	1.970	1.971	1.970	1.969	1.970	1.969
456	1.969	1.970	1.969	1.970	1.970	1.970	1.969	1.969	1.970
457	1.969	1.970	1.969	1.970	1.970	1.970	1.969	1.970	1.969

TABLE F3 (continued)

458	1.953	1.958	1.953	1.958	1.959	1.958	1.953	1.957	1.956
459	1.954	1.959	1.954	1.957	1.959	1.958	1.954	1.958	1.958
460	1.955	1.959	1.953	1.958	1.959	1.959	1.954	1.959	1.958
461	1.954	1.959	1.953	1.958	1.959	1.959	1.954	1.958	1.957
462	1.954	1.958	1.953	1.958	1.960	1.960	1.954	1.958	1.958
463	1.956	1.959	1.956	1.959	1.960	1.960	1.956	1.959	1.958
464	1.958	1.959	1.957	1.959	1.960	1.960	1.958	1.960	1.959
465	1.957	1.959	1.954	1.959	1.960	1.960	1.956	1.959	1.959
466	1.958	1.959	1.957	1.958	1.960	1.960	1.956	1.959	1.959
467	1.957	1.959	1.957	1.959	1.960	1.960	1.957	1.959	1.959
468	1.958	1.959	1.956	1.959	1.960	1.960	1.955	1.959	1.959
469	1.958	1.959	1.955	1.956	1.960	1.960	1.955	1.959	1.958
470	1.954	1.958	1.952	1.955	1.958	1.958	1.952	1.957	1.955
471	1.993	1.997	1.992	1.995	1.997	1.994	1.991	1.994	1.993
472	1.991	1.994	1.990	1.992	1.994	1.992	1.990	1.992	1.991
473	1.989	1.990	1.988	1.989	1.990	1.989	1.985	1.989	1.985
474	1.988	1.989	1.985	1.988	1.990	1.988	1.985	1.988	1.987
475	1.987	1.989	1.984	1.988	1.989	1.987	1.984	1.988	1.987
476	1.985	1.988	1.984	1.988	1.988	1.987	1.983	1.986	1.987
477	1.984	1.988	1.982	1.986	1.988	1.984	1.982	1.985	1.983
478	1.982	1.987	1.981	1.984	1.986	1.984	1.981	1.984	1.983
479	1.982	1.986	1.982	1.983	1.987	1.984	1.981	1.984	1.983
480	1.973	1.978	1.972	1.975	1.978	1.974	1.972	1.975	1.973
481	1.973	1.977	1.971	1.975	1.977	1.975	1.971	1.975	1.974
482	1.973	1.978	1.972	1.975	1.978	1.975	1.972	1.975	1.974
483	1.973	1.978	1.972	1.974	1.977	1.975	1.972	1.975	1.974
484	2.021	2.024	2.021	2.023	2.026	2.024	2.021	2.024	2.023
485	2.022	2.024	2.021	2.024	2.027	2.024	2.021	2.024	2.022
486	2.021	2.024	2.021	2.023	2.026	2.024	2.021	2.024	2.023
487	2.021	2.024	2.021	2.023	2.025	2.023	2.021	2.023	2.022
488	2.020	2.023	2.020	2.022	2.025	2.023	2.020	2.023	2.022
489	2.020	2.022	2.020	2.021	2.023	2.022	2.019	2.021	2.021
490	2.020	2.022	2.019	2.021	2.023	2.022	2.019	2.021	2.021
491	2.019	2.021	2.019	2.020	2.023	2.021	2.019	2.021	2.021
492	2.019	2.021	2.019	2.020	2.023	2.021	2.019	2.021	2.020
493	2.018	2.020	2.018	2.019	2.021	2.019	2.017	2.019	2.019
494	2.018	2.019	2.017	2.019	2.021	2.020	2.016	2.019	2.019
495	2.018	2.020	2.017	2.019	2.021	2.020	2.017	2.019	2.019
496	2.017	2.018	2.015	2.018	2.020	2.019	2.015	2.019	2.018
497	1.669	1.670	1.668	1.669	1.670	1.670	1.668	1.669	1.669
498	1.668	1.669	1.668	1.668	1.669	1.669	1.667	1.669	1.669
499	1.667	1.669	1.668	1.668	1.669	1.666	1.667	1.669	1.666
500	1.668	1.669	1.667	1.668	1.669	1.666	1.665	1.668	1.667
501	1.667	1.668	1.666	1.668	1.668	1.668	1.665	1.663	1.667
502	1.665	1.668	1.666	1.668	1.668	1.666	1.665	1.668	1.668
503	1.663	1.664	1.662	1.663	1.664	1.663	1.661	1.663	1.661
504	1.663	1.664	1.662	1.663	1.664	1.664	1.662	1.664	1.663
505	1.662	1.665	1.662	1.664	1.666	1.664	1.662	1.664	1.664
506	1.662	1.664	1.663	1.664	1.666	1.665	1.663	1.664	1.664
507	1.662	1.664	1.662	1.664	1.666	1.664	1.663	1.664	1.664
508	1.662	1.664	1.663	1.664	1.665	1.664	1.662	1.664	1.664
509	1.662	1.664	1.662	1.664	1.665	1.665	1.662	1.664	1.664
510	2.029	2.031	2.030	2.031	2.032	2.031	2.029	2.031	2.030
511	2.029	2.031	2.029	2.031	2.033	2.031	2.029	2.031	2.030
512	2.030	2.032	2.030	2.031	2.033	2.031	2.029	2.031	2.031
513	2.030	2.031	2.030	2.031	2.033	2.032	2.029	2.031	2.031
514	2.030	2.031	2.030	2.031	2.033	2.032	2.029	2.031	2.031
515	2.030	2.032	2.030	2.031	2.033	2.032	2.029	2.031	2.031
516	2.030	2.032	2.030	2.031	2.032	2.031	2.029	2.031	2.031
517	2.029	2.031	2.029	2.031	2.032	2.031	2.029	2.031	2.030
518	2.029	2.031	2.029	2.030	2.032	2.031	2.029	2.031	2.031
519	2.030	2.032	2.030	2.031	2.034	2.033	2.030	2.031	2.031
520	2.030	2.032	2.030	2.031	2.033	2.032	2.030	2.031	2.031
521	2.030	2.032	2.030	2.031	2.034	2.033	2.030	2.031	2.031
522	2.030	2.032	2.030	2.031	2.034	2.032	2.030	2.031	2.031
523	1.948	1.949	1.947	1.947	1.949	1.948	1.946	1.949	1.949
524	1.948	1.949	1.947	1.948	1.949	1.948	1.947	1.949	1.949
525	1.947	1.949	1.947	1.948	1.950	1.948	1.946	1.949	1.949
526	1.945	1.947	1.944	1.945	1.948	1.945	1.943	1.948	1.948
527	1.945	1.948	1.944	1.946	1.948	1.947	1.943	1.947	1.947
528	1.944	1.948	1.944	1.945	1.948	1.945	1.943	1.946	1.946
529	1.943	1.947	1.943	1.944	1.948	1.944	1.942	1.946	1.946
530	1.943	1.947	1.943	1.944	1.948	1.944	1.942	1.946	1.946
531	1.942	1.947	1.943	1.944	1.946	1.945	1.942	1.947	1.946
532	1.941	1.943	1.941	1.942	1.944	1.942	1.940	1.943	1.943
533	1.941	1.943	1.941	1.942	1.944	1.942	1.940	1.943	1.943
534	1.941	1.943	1.941	1.941	1.944	1.942	1.940	1.943	1.943

TABLE F3 (continued)

535	1.941	1.943	1.941	1.942	1.944	1.943	1.940	1.942	1.942
536	2.084	2.089	2.087	2.087	2.090	2.089	2.084	2.089	2.087
537	2.084	2.089	2.085	2.088	2.090	2.089	2.084	2.089	2.087
538	2.084	2.089	2.085	2.087	2.090	2.089	2.084	2.088	2.087
539	2.083	2.088	2.085	2.087	2.090	2.089	2.082	2.083	2.086
540	2.083	2.089	2.086	2.087	2.089	2.089	2.083	2.088	2.085
541	2.084	2.089	2.087	2.088	2.090	2.089	2.083	2.089	2.087
542	2.084	2.089	2.087	2.088	2.090	2.090	2.083	2.089	2.088
543	2.084	2.089	2.087	2.089	2.090	2.090	2.086	2.089	2.088
544	4.413	4.460	4.467	4.434	4.474	4.477	4.410	4.459	4.462
545	4.420	4.468	4.471	4.441	4.480	4.482	4.417	4.467	4.469
546	4.423	4.471	4.474	4.446	4.485	4.489	4.421	4.470	4.473
547	4.426	4.473	4.479	4.449	4.489	4.490	4.423	4.472	4.477
548	4.423	4.470	4.473	4.443	4.484	4.486	4.419	4.470	4.473
549	1.731	1.734	1.732	1.733	1.735	1.734	1.732	1.734	1.733
550	1.732	1.736	1.734	1.734	1.737	1.736	1.734	1.736	1.736
551	1.733	1.737	1.736	1.737	1.739	1.739	1.734	1.737	1.737
552	1.737	1.739	1.739	1.739	1.740	1.739	1.738	1.739	1.739
553	1.739	1.740	1.739	1.740	1.740	1.740	1.739	1.740	1.740
554	1.739	1.740	1.740	1.740	1.741	1.740	1.739	1.740	1.740
555	1.740	1.741	1.740	1.740	1.742	1.741	1.740	1.741	1.741
556	1.989	1.991	1.989	1.991	1.992	1.992	1.989	1.991	1.991
557	1.989	1.992	1.990	1.991	1.994	1.993	1.989	1.992	1.992
558	1.990	1.994	1.992	1.992	1.994	1.994	1.990	1.993	1.993
559	1.990	1.994	1.992	1.994	1.997	1.994	1.991	1.994	1.994
560	1.990	1.995	1.992	1.994	1.997	1.996	1.992	1.994	1.994
561	1.990	1.995	1.993	1.994	1.997	1.997	1.991	1.995	1.994
562	1.991	1.995	1.993	1.994	1.997	1.997	1.991	1.994	1.993
563	1.689	1.689	1.688	1.689	1.690	1.690	1.689	1.690	1.689
564	1.689	1.670	1.689	1.690	1.691	1.690	1.689	1.690	1.690
565	1.689	1.690	1.689	1.690	1.691	1.690	1.689	1.691	1.691
566	1.689	1.691	1.690	1.691	1.692	1.691	1.690	1.691	1.690
567	1.690	1.692	1.690	1.692	1.692	1.691	1.690	1.692	1.692
568	2.261	2.268	2.262	2.264	2.268	2.267	2.261	2.266	2.265
569	2.267	2.271	2.268	2.269	2.272	2.270	2.267	2.270	2.270
570	2.269	2.273	2.269	2.270	2.273	2.273	2.269	2.272	2.272
571	2.270	2.277	2.271	2.273	2.278	2.274	2.270	2.275	2.275
572	2.272	2.278	2.274	2.277	2.279	2.278	2.273	2.278	2.278
573	2.275	2.280	2.278	2.279	2.282	2.280	2.276	2.280	2.280
574	2.278	2.281	2.278	2.280	2.283	2.282	2.278	2.281	2.281
575	2.278	2.283	2.279	2.280	2.284	2.281	2.278	2.281	2.281
576	2.562	2.569	2.562	2.565	2.570	2.568	2.562	2.568	2.568
577	2.563	2.570	2.564	2.567	2.572	2.569	2.562	2.569	2.569
578	2.563	2.570	2.566	2.568	2.572	2.570	2.563	2.570	2.569
579	2.565	2.571	2.567	2.569	2.572	2.570	2.563	2.570	2.570
580	2.565	2.572	2.567	2.569	2.573	2.571	2.565	2.571	2.571
581	2.567	2.573	2.568	2.570	2.574	2.572	2.567	2.572	2.572
582	2.568	2.573	2.569	2.570	2.577	2.572	2.568	2.573	2.573
583	2.569	2.575	2.569	2.572	2.578	2.574	2.568	2.573	2.573
584	2.469	2.473	2.470	2.468	2.470	2.468	2.463	2.467	2.468
585	2.464	2.470	2.467	2.463	2.468	2.466	2.461	2.463	2.464
586	2.463	2.470	2.467	2.463	2.467	2.464	2.461	2.463	2.463
587	2.461	2.469	2.462	2.460	2.462	2.460	2.458	2.460	2.460
588	2.460	2.468	2.461	2.459	2.462	2.460	2.458	2.460	2.459
589	3.386	3.394	3.387	3.378	3.384	3.380	3.373	3.379	3.379
590	3.383	3.392	3.384	3.376	3.381	3.379	3.373	3.378	3.378
591	3.380	3.390	3.383	3.374	3.380	3.378	3.370	3.375	3.377
592	3.380	3.389	3.381	3.373	3.379	3.376	3.370	3.374	3.374
593	3.379	3.389	3.380	3.372	3.379	3.376	3.370	3.373	3.373
594	3.378	3.388	3.380	3.371	3.378	3.374	3.369	3.373	3.373
595	4.708	4.728	4.716	4.693	4.709	4.703	4.690	4.700	4.702
596	4.707	4.729	4.714	4.694	4.709	4.702	4.689	4.698	4.701
597	4.704	4.724	4.713	4.692	4.705	4.702	4.688	4.698	4.700
598	4.704	4.724	4.713	4.691	4.705	4.701	4.687	4.697	4.699
599	2.954	2.963	2.959	2.949	2.955	2.954	2.948	2.951	2.953
600	2.956	2.964	2.960	2.950	2.958	2.956	2.949	2.952	2.954
601	2.957	2.964	2.960	2.951	2.958	2.956	2.950	2.954	2.957
602	2.957	2.966	2.961	2.953	2.959	2.958	2.951	2.956	2.958
603	2.960	2.970	2.964	2.957	2.962	2.961	2.954	2.959	2.960
604	2.961	2.971	2.967	2.958	2.963	2.962	2.956	2.960	2.961
605	2.463	2.471	2.468	2.465	2.471	2.469	2.461	2.469	2.469
606	2.464	2.471	2.468	2.467	2.471	2.470	2.463	2.469	2.470
607	2.466	2.472	2.470	2.467	2.473	2.470	2.464	2.470	2.470
608	2.467	2.472	2.469	2.468	2.473	2.471	2.464	2.470	2.471
609	2.467	2.473	2.470	2.468	2.473	2.470	2.464	2.470	2.471
610	2.467	2.472	2.470	2.468	2.472	2.470	2.464	2.470	2.470
611	2.959	2.969	2.962	2.960	2.969	2.963	2.956	2.964	2.964

TABLE F3 (continued)

612	2.960	2.970	2.963	2.960	2.970	2.965	2.958	2.967	2.968
613	2.960	2.970	2.964	2.961	2.971	2.966	2.959	2.968	2.969
614	2.961	2.971	2.965	2.962	2.972	2.968	2.959	2.968	2.969
615	2.962	2.972	2.967	2.963	2.972	2.969	2.960	2.969	2.969
616	2.963	2.973	2.969	2.964	2.973	2.970	2.960	2.969	2.970
617	3.390	3.402	3.398	3.390	3.403	3.399	3.388	3.398	3.400
618	3.390	3.403	3.398	3.391	3.403	3.399	3.388	3.399	3.400
619	3.392	3.404	3.399	3.392	3.405	3.400	3.389	3.400	3.402
620	3.392	3.406	3.399	3.393	3.407	3.401	3.390	3.401	3.402
621	3.394	3.408	3.401	3.397	3.409	3.403	3.392	3.403	3.402
622	3.397	3.409	3.402	3.398	3.410	3.405	3.393	3.403	3.407
623	4.699	4.722	4.717	4.700	4.726	4.717	4.696	4.720	4.723
624	4.709	4.732	4.722	4.708	4.732	4.723	4.702	4.725	4.730
625	4.711	4.734	4.723	4.709	4.734	4.724	4.704	4.729	4.732
626	4.713	4.739	4.728	4.711	4.738	4.726	4.709	4.730	4.734
627	4.716	4.739	4.728	4.713	4.739	4.728	4.709	4.731	4.736
628	4.720	4.742	4.732	4.717	4.741	4.731	4.712	4.734	4.740
629	2.700	2.709	2.706	2.701	2.710	2.709	2.699	2.708	2.709
630	2.700	2.710	2.708	2.701	2.711	2.709	2.700	2.709	2.709
631	2.701	2.711	2.709	2.703	2.712	2.710	2.701	2.709	2.710
632	2.702	2.711	2.709	2.702	2.713	2.710	2.701	2.710	2.710
633	2.703	2.713	2.710	2.705	2.714	2.711	2.702	2.710	2.712
634	2.704	2.714	2.710	2.705	2.714	2.712	2.704	2.711	2.712
635	2.894	2.901	2.898	2.898	2.901	2.899	2.895	2.899	2.899
636	2.898	2.903	2.899	2.899	2.903	2.901	2.898	2.900	2.900
637	2.898	2.903	2.900	2.899	2.903	2.901	2.898	2.901	2.901
638	2.899	2.903	2.899	2.899	2.903	2.901	2.898	2.901	2.901
639	2.899	2.904	2.900	2.900	2.906	2.901	2.898	2.902	2.902
640	2.900	2.906	2.902	2.901	2.907	2.903	2.899	2.902	2.902
641	3.192	3.199	3.193	3.193	3.199	3.196	3.190	3.196	3.196
642	3.193	3.200	3.195	3.195	3.200	3.197	3.192	3.197	3.198
643	3.194	3.200	3.195	3.195	3.201	3.196	3.192	3.198	3.198
644	3.194	3.200	3.196	3.196	3.201	3.196	3.192	3.198	3.198
645	3.195	3.201	3.197	3.196	3.201	3.199	3.193	3.199	3.198
646	3.196	3.201	3.197	3.196	3.201	3.199	3.193	3.199	3.199
647	3.663	3.672	3.664	3.664	3.671	3.666	3.660	3.667	3.667
648	3.664	3.672	3.665	3.664	3.672	3.668	3.661	3.668	3.668
649	3.664	3.673	3.667	3.664	3.673	3.666	3.661	3.668	3.668
650	3.664	3.672	3.667	3.665	3.672	3.668	3.661	3.668	3.668
651	3.666	3.673	3.668	3.666	3.673	3.666	3.663	3.669	3.669
652	3.666	3.674	3.668	3.666	3.673	3.669	3.663	3.669	3.669
653	4.219	4.227	4.220	4.219	4.228	4.220	4.213	4.221	4.221
654	4.219	4.229	4.220	4.219	4.228	4.221	4.214	4.222	4.223
655	4.220	4.230	4.221	4.220	4.229	4.222	4.218	4.222	4.223
656	4.220	4.230	4.221	4.220	4.229	4.222	4.216	4.223	4.224
657	4.220	4.230	4.221	4.220	4.230	4.223	4.217	4.223	4.224
658	4.221	4.230	4.222	4.220	4.230	4.223	4.218	4.223	4.224
659	6.102	6.119	6.107	6.092	6.113	6.102	6.092	6.109	6.110
660	6.103	6.120	6.108	6.093	6.113	6.103	6.093	6.109	6.112
661	6.103	6.120	6.109	6.096	6.115	6.104	6.094	6.109	6.112
662	6.103	6.121	6.110	6.095	6.114	6.107	6.096	6.110	6.113
663	6.105	6.121	6.110	6.096	6.116	6.107	6.097	6.110	6.113
664	6.109	6.124	6.112	6.099	6.120	6.109	6.099	6.112	6.118
665	1.574	1.579	1.579	1.574	1.579	1.579	1.574	1.578	1.579
666	1.577	1.580	1.580	1.576	1.580	1.580	1.576	1.578	1.580
667	1.578	1.581	1.580	1.577	1.580	1.580	1.576	1.579	1.580
668	1.579	1.581	1.581	1.579	1.582	1.581	1.579	1.580	1.581
669	1.580	1.584	1.583	1.579	1.582	1.582	1.579	1.580	1.582
670	1.722	1.729	1.728	1.721	1.729	1.729	1.720	1.723	1.727
671	1.722	1.729	1.729	1.723	1.729	1.729	1.721	1.726	1.728
672	1.724	1.731	1.731	1.723	1.730	1.730	1.722	1.727	1.729
673	1.724	1.731	1.730	1.723	1.730	1.730	1.723	1.728	1.729
674	1.726	1.732	1.731	1.724	1.731	1.731	1.723	1.729	1.730
675	2.092	2.106	2.103	2.089	2.102	2.102	2.087	2.096	2.100
676	2.094	2.108	2.106	2.090	2.103	2.103	2.089	2.097	2.101
677	2.096	2.109	2.107	2.091	2.105	2.104	2.089	2.098	2.102
678	2.098	2.110	2.109	2.093	2.107	2.107	2.090	2.099	2.103
679	1.699	1.700	1.700	1.698	1.699	1.700	1.698	1.699	1.700
680	1.699	1.700	1.700	1.698	1.700	1.700	1.698	1.699	1.700
681	1.699	1.701	1.700	1.699	1.700	1.700	1.699	1.700	1.701
682	1.699	1.701	1.701	1.699	1.701	1.701	1.699	1.701	1.702
683	1.699	1.702	1.702	1.699	1.702	1.702	1.700	1.701	1.702
684	1.700	1.702	1.702	1.700	1.702	1.702	1.700	1.701	1.702
685	1.936	1.940	1.940	1.937	1.940	1.940	1.937	1.939	1.940
686	1.939	1.941	1.941	1.938	1.941	1.942	1.938	1.940	1.941
687	1.939	1.942	1.943	1.939	1.942	1.942	1.940	1.941	1.943
688	1.939	1.943	1.942	1.939	1.942	1.942	1.940	1.942	1.943

TABLE F3 (continued)

689	1.939	1.943	1.943	1.940	1.944	1.943	1.941	1.942	1.944
690	1.940	1.944	1.944	1.941	1.944	1.944	1.942	1.944	1.945
691	2.238	2.243	2.241	2.237	2.242	2.241	2.238	2.241	2.242
692	2.239	2.244	2.243	2.239	2.244	2.243	2.240	2.242	2.244
693	2.240	2.246	2.245	2.240	2.246	2.246	2.241	2.244	2.247
694	2.241	2.247	2.246	2.240	2.247	2.245	2.241	2.244	2.247
695	2.240	2.246	2.245	2.240	2.246	2.245	2.240	2.244	2.247
696	2.241	2.247	2.244	2.240	2.245	2.244	2.240	2.243	2.247
697	2.556	2.562	2.561	2.553	2.561	2.560	2.554	2.559	2.562
698	2.557	2.563	2.563	2.555	2.563	2.563	2.557	2.561	2.564
699	2.559	2.567	2.565	2.558	2.566	2.566	2.559	2.563	2.567
700	2.560	2.567	2.567	2.559	2.568	2.566	2.560	2.565	2.568
701	2.561	2.569	2.568	2.560	2.569	2.568	2.561	2.566	2.569
702	2.561	2.569	2.568	2.560	2.569	2.568	2.561	2.566	2.570
703	1.679	1.680	1.680	1.680	1.681	1.681	1.680	1.680	1.681
704	1.681	1.683	1.683	1.683	1.684	1.684	1.682	1.683	1.683
705	1.682	1.683	1.683	1.683	1.683	1.684	1.683	1.683	1.683
706	1.683	1.684	1.684	1.683	1.684	1.685	1.683	1.683	1.685
707	1.683	1.686	1.685	1.684	1.686	1.687	1.684	1.687	1.687
708	1.685	1.687	1.687	1.686	1.688	1.686	1.686	1.688	1.688
709	1.908	1.910	1.910	1.909	1.910	1.911	1.908	1.910	1.910
710	1.909	1.911	1.911	1.910	1.912	1.912	1.910	1.912	1.912
711	1.909	1.912	1.912	1.911	1.913	1.913	1.911	1.913	1.913
712	1.909	1.913	1.913	1.911	1.913	1.913	1.911	1.913	1.913
713	1.910	1.912	1.913	1.911	1.914	1.914	1.911	1.913	1.913
714	1.910	1.913	1.913	1.912	1.914	1.914	1.912	1.913	1.914
715	2.231	2.237	2.234	2.232	2.238	2.237	2.232	2.237	2.237
716	2.231	2.237	2.237	2.233	2.249	2.248	2.233	2.248	2.246
717	2.232	2.238	2.237	2.234	2.239	2.239	2.234	2.238	2.239
718	2.233	2.239	2.238	2.234	2.239	2.239	2.235	2.238	2.239
719	2.233	2.239	2.238	2.235	2.240	2.240	2.236	2.240	2.240
720	2.234	2.239	2.239	2.236	2.240	2.240	2.237	2.240	2.240
721	1.685	1.688	1.688	1.688	1.689	1.689	1.686	1.689	1.689
722	1.686	1.689	1.689	1.688	1.689	1.689	1.688	1.689	1.689
723	1.688	1.690	1.690	1.689	1.690	1.690	1.689	1.690	1.690
724	1.689	1.690	1.690	1.690	1.691	1.691	1.690	1.691	1.691
725	1.689	1.690	1.690	1.690	1.692	1.691	1.691	1.691	1.691
726	1.690	1.692	1.692	1.692	1.694	1.693	1.692	1.693	1.692
727	1.910	1.912	1.912	1.912	1.913	1.913	1.911	1.913	1.914
728	1.911	1.914	1.913	1.913	1.917	1.916	1.913	1.916	1.916
729	1.912	1.916	1.914	1.914	1.918	1.917	1.915	1.918	1.916
730	1.913	1.917	1.917	1.917	1.919	1.918	1.916	1.919	1.919
731	1.913	1.918	1.917	1.916	1.920	1.919	1.918	1.920	1.920
732	1.914	1.919	1.917	1.918	1.920	1.920	1.919	1.920	1.920
733	2.231	2.235	2.233	2.234	2.239	2.237	2.233	2.239	2.238
734	2.231	2.236	2.234	2.234	2.239	2.237	2.234	2.238	2.238
735	2.231	2.237	2.235	2.235	2.239	2.239	2.235	2.239	2.239
736	2.232	2.239	2.236	2.236	2.240	2.239	2.237	2.240	2.240
737	2.233	2.239	2.237	2.237	2.241	2.240	2.237	2.240	2.240
738	2.234	2.240	2.239	2.238	2.242	2.240	2.239	2.241	2.241

TABLE F4

THE MEAN AND STD DEVIATIUN OF MILLIVOLT POSNS 1 TO9

K	XBAR	STD	TEMP	K	XBAR	STD	TEMP	K	XBAR	STD	TEMP
1	1.97867	0.00112	49.348	2	1.98222	0.00164	49.433	3	1.98344	0.00151	49.463
4	1.98567	0.00112	49.516	5	1.98644	0.00151	49.535	6	1.98733	0.00122	49.556
7	1.98767	0.00141	49.505	8	1.99167	0.00166	49.660	9	1.98889	0.00093	49.593
10	1.98889	0.00105	49.593	11	1.99011	0.00105	49.623	12	1.99044	0.00142	49.631
13	1.99078	0.00164	49.639	14	1.99033	0.00158	49.626	15	1.98956	0.00113	49.609
16	1.98956	0.00159	49.609	17	1.98967	0.00122	49.612	18	1.99044	0.00124	49.631
19	1.99044	0.00113	49.631	20	1.98922	0.00120	49.601	21	1.98967	0.00132	49.612
22	1.99133	0.00150	49.652	23	1.99289	0.00105	49.689	24	1.99344	0.00101	49.703
25	1.99311	0.00136	49.695	26	1.99267	0.00112	49.684	27	1.99289	0.00154	49.689
28	1.99244	0.00113	49.679	29	1.46333	0.00071	36.812	30	1.45967	0.00050	36.722
31	1.45333	0.00141	36.506	32	1.44833	0.00071	36.443	33	1.44789	0.00033	36.432
34	1.43567	0.00071	36.130	35	1.43778	0.00067	36.182	36	1.43800	0.00000	36.188
37	1.43889	0.00033	36.210	38	1.43967	0.00050	36.229	39	1.44069	0.00033	36.259
40	1.44069	0.00033	36.259	41	1.44100	0.00000	36.262	42	1.44289	0.00033	36.308
43	2.38844	0.00113	59.069	44	2.38744	0.00159	59.066	45	2.38756	0.00133	59.069
46	2.38756	0.00133	59.069	47	2.38767	0.00173	59.071	48	2.38767	0.00180	59.071
49	2.38667	0.00206	59.048	50	2.39300	0.00166	59.197	51	2.39156	0.00161	59.163
52	2.39122	0.00164	59.155	53	2.38978	0.00130	59.121	54	2.38844	0.00124	59.089
55	2.38867	0.00100	59.095	56	2.02967	0.00067	50.571	57	2.02556	0.00113	50.472
58	2.02111	0.00145	50.366	59	2.01889	0.00117	50.313	60	2.01711	0.00105	50.270
61	2.03900	0.00100	50.794	62	2.03378	0.00130	50.669	63	2.03033	0.00100	50.587
64	2.02911	0.00093	50.556	65	2.02833	0.00112	50.539	66	2.02400	0.00122	50.435
67	2.02333	0.00112	50.419	68	2.02256	0.00113	50.401	69	2.01769	0.00076	50.289
70	2.01633	0.00122	50.251	71	2.01433	0.00100	50.204	72	2.01289	0.00117	50.169
73	2.01244	0.00124	50.158	74	2.00989	0.00000	50.097	75	2.00611	0.00117	50.006
76	2.00678	0.00120	50.022	77	2.00667	0.00100	50.020	78	2.00011	0.00093	49.863
79	2.00222	0.00120	49.913	80	2.00244	0.00113	49.915	81	1.96000	0.00100	48.899
82	1.94689	0.00127	48.584	83	1.95356	0.00142	48.745	84	1.95067	0.00100	48.675
85	1.94633	0.00132	48.571	86	1.94544	0.00142	48.550	87	1.94556	0.00159	48.552
88	1.95544	0.00188	49.030	89	1.95556	0.00088	48.865	90	1.95156	0.00101	48.696
91	1.95033	0.00112	48.667	92	1.94978	0.00067	48.654	93	1.95433	0.00132	48.763
94	1.43011	0.00033	35.993	95	1.43511	0.00078	36.116	96	1.43444	0.00073	36.100
97	1.44000	0.00000	36.237	98	1.43989	0.00033	36.234	99	1.43933	0.00071	36.220
100	1.43889	0.00033	36.210	101	1.43078	0.00044	36.009	102	1.43678	0.00067	36.157
103	1.43767	0.00100	36.179	104	1.43744	0.00101	36.174	105	1.43722	0.00130	36.168
106	1.43467	0.00050	36.105	107	2.32044	0.00113	57.675	108	2.32322	0.00186	57.552
109	2.31778	0.00199	57.423	110	2.33156	0.00142	57.749	111	2.32467	0.00250	57.586
112	2.31867	0.00141	57.444	113	2.31278	0.00192	57.305	114	2.30867	0.00087	57.203
115	2.30589	0.00237	57.142	116	2.30189	0.00154	57.048	117	2.29956	0.00086	56.993
118	2.29278	0.00172	56.832	119	2.29156	0.00107	56.803	120	1.99433	0.00141	49.724
121	1.99067	0.00087	49.636	122	1.98622	0.00166	49.529	123	1.98067	0.00056	49.398
124	1.97533	0.00141	49.268	125	1.97156	0.00068	49.177	126	1.96989	0.00060	49.137
127	1.97056	0.00073	49.153	128	1.99044	0.00073	49.631	129	1.98878	0.00083	49.591
130	1.98600	0.00180	49.524	131	1.98078	0.00067	49.399	132	1.97469	0.00162	49.257
133	1.97789	0.00127	49.329	134	1.97411	0.00162	49.236	135	1.97122	0.00083	49.169
136	1.97811	0.00136	49.335	137	1.97222	0.00130	49.193	138	1.95767	0.00187	48.843
139	1.97878	0.00083	49.351	140	1.97578	0.00156	49.279	141	1.96976	0.00044	49.134
142	1.96556	0.00159	49.033	143	1.96000	0.00071	48.899	144	1.95633	0.00173	48.811
145	1.95467	0.00150	48.771	146	1.95589	0.00154	48.801	147	1.95367	0.00160	48.747
148	1.94911	0.00078	48.638	149	1.94911	0.00105	48.638	150	1.94767	0.00141	48.603
151	1.94689	0.00162	48.564	152	1.94544	0.00174	48.550	153	1.94411	0.00176	48.517
154	1.94189	0.00117	48.464	155	1.94256	0.00113	48.480	156	1.94189	0.00070	48.464
157	1.95744	0.00124	48.838	158	1.95278	0.00130	48.726	159	1.95056	0.00113	48.672
160	1.94767	0.00087	48.603	161	1.94289	0.00078	48.488	162	1.93678	0.00083	48.389
163	1.93778	0.00120	48.305	164	1.93344	0.00142	48.261	165	1.93056	0.00053	48.191
166	1.92556	0.00133	48.071	167	1.92433	0.00158	48.042	168	1.92033	0.00087	47.945
169	1.92022	0.00067	47.943	170	1.92267	0.00132	48.001	171	1.92300	0.00112	48.009
172	1.41722	0.00067	35.075	173	1.41356	0.00053	35.564	174	1.41000	0.00000	35.496
175	1.40900	0.00000	35.471	176	1.40844	0.00053	35.456	177	1.40689	0.00033	35.419
178	1.40689	0.00033	35.419	179	1.40689	0.00060	35.419	180	1.40689	0.00033	35.419
181	1.40789	0.00078	35.444	182	1.40778	0.00044	35.441	183	1.40789	0.00033	35.444
184	1.40744	0.00167	35.433	185	2.26089	0.00127	56.076	186	2.28756	0.00167	56.236
187	2.26644	0.00207	56.209	188	2.28789	0.00127	56.717	189	2.27222	0.00150	56.340
190	2.30989	0.00136	57.237	191	2.30078	0.00139	57.022	192	2.29367	0.00173	56.853
193	2.27678	0.00192	56.454	194	2.27144	0.00113	56.328	195	2.26822	0.00140	56.251
196	2.26056	0.00201	56.212	197	2.26733	0.00173	56.230	198	1.94122	0.00109	48.448
199	1.93889	0.00078	48.392	200	1.93033	0.00160	48.330	201	1.93278	0.00130	48.245
202	1.93089	0.00078	48.199	203	1.92922	0.00063	48.159	204	1.92689	0.00076	48.151
205	1.92800	0.00112	48.130	206	1.92700	0.00132	48.106	207	1.92478	0.00130	48.052
208	1.92433	0.00122	48.042	209	1.92344	0.00124	48.020	210	1.91967	0.00050	47.929

211	1.92622	0.00130	48.067	212	1.92811	0.00093	48.132	213	1.92700	0.00100	48.106
214	1.92700	0.00100	48.106	215	1.92711	0.00105	48.108	216	1.94811	0.00060	48.614
217	1.94300	0.00087	48.491	218	1.94056	0.00058	48.432	219	1.93856	0.00073	48.384
220	1.93378	0.00130	48.269	221	1.93300	0.00067	48.250	222	1.93067	0.00071	48.194
223	1.92811	0.00078	48.132	224	1.92200	0.00067	47.985	225	1.92200	0.00071	47.985
226	1.92022	0.00067	47.943	227	1.92200	0.00071	47.985	228	1.92222	0.00067	47.991
229	1.91789	0.00093	47.886	230	1.91900	0.00050	47.913	231	1.91911	0.00070	47.916
232	1.92278	0.00067	48.004	233	1.92389	0.00078	48.031	234	1.92511	0.00127	48.060
235	1.92389	0.00093	48.031	236	1.92578	0.00130	48.076	237	1.91944	0.00073	47.924
238	1.91500	0.00150	47.817	239	1.91156	0.00058	47.734	240	1.91022	0.00067	47.702
241	1.91822	0.00067	47.894	242	1.91856	0.00058	47.902	243	1.91833	0.00100	47.897
244	1.91822	0.00083	47.894	245	1.91878	0.00067	47.908	246	1.91900	0.00087	47.913
247	1.91878	0.00083	47.908	248	1.91933	0.00071	47.921	249	1.91944	0.00073	47.924
250	1.40767	0.00071	35.438	251	1.40789	0.00033	35.44[illegible]	252	1.40711	0.00033	35.425
253	1.40678	0.00044	35.416	254	1.40644	0.00058	35.408	255	1.40389	0.00033	35.345
256	1.40389	0.00033	35.345	257	1.40311	0.00033	35.326	258	1.40311	0.00033	35.326
259	1.40133	0.00050	35.282	260	1.40189	0.00033	35.296	261	1.40189	0.00033	35.296
262	1.40189	0.00033	35.296	263	2.26144	0.00101	56.091	264	2.26267	0.00141	56.120
265	2.26756	0.00151	56.236	266	2.26822	0.00130	56.251	267	2.26878	0.00109	56.265
268	2.26944	0.00101	56.280	269	2.26922	0.00120	56.275	270	2.27044	0.00080	56.304
271	2.27067	0.00100	56.309	272	2.27089	0.00127	56.315	273	2.27111	0.00145	56.320
274	2.26978	0.00120	56.288	275	2.26956	0.00058	56.283	276	1.95722	0.00130	48.833
277	1.95556	0.00142	48.793	278	1.95500	0.00150	48.779	279	1.95256	0.00080	48.721
280	1.95144	0.00088	48.694	281	1.94989	0.00060	48.656	282	1.94889	0.00060	48.632
283	1.94278	0.00097	48.465	284	1.94356	0.00058	48.504	285	1.94269	0.00073	48.468
286	1.94544	0.00133	48.550	287	1.94678	0.00148	48.582	288	1.94711	0.00105	48.590
289	1.93211	0.00078	48.229	290	1.93344	0.00133	48.261	291	1.93244	0.00086	48.237
292	1.93189	0.00093	48.223	293	1.95389	0.00117	48.753	294	1.95211	0.00117	48.710
295	1.94867	0.00087	48.627	296	1.94500	0.00132	48.539	297	1.94144	0.00073	48.453
298	1.93178	0.00097	48.221	299	1.93167	0.00112	48.218	300	1.93033	0.00071	48.186
301	1.93022	0.00067	48.183	302	1.92200	0.00100	47.985	303	1.92222	0.00109	47.991
304	1.91967	0.00050	47.929	305	1.91967	0.00050	47.929	306	1.91978	0.00044	47.932
307	1.91200	0.00087	47.744	308	1.91189	0.00078	47.742	309	1.91233	0.00112	47.753
310	1.91356	0.00124	47.782	311	1.91567	0.00160	47.833	312	1.91569	0.00162	47.833
313	1.91544	0.00151	47.827	314	1.91467	0.00150	47.809	315	1.95333	0.00087	48.739
316	1.95533	0.00166	48.787	317	1.95789	0.00078	48.849	318	1.95822	0.00063	48.857
319	1.95833	0.00071	48.859	320	1.95922	0.00067	48.881	321	1.95967	0.00071	48.891
322	1.96078	0.00067	48.916	323	1.96111	0.00105	48.926	324	1.96089	0.00070	48.921
325	1.96111	0.00060	48.926	326	1.96511	0.00127	49.022	327	1.96722	0.00139	49.073
328	1.42400	0.00000	35.842	329	1.42400	0.00000	35.842	330	1.42344	0.00073	35.828
331	1.42300	0.00000	35.817	332	1.42344	0.00053	35.828	333	1.42356	0.00053	35.831
334	1.42356	0.00053	35.831	335	1.42222	0.00044	35.798	336	1.42300	0.00000	35.817
337	1.42289	0.00033	35.814	338	1.42222	0.00044	35.798	339	1.42333	0.00087	35.825
340	1.42311	0.00033	35.820	341	2.35022	0.00120	58.370	342	2.35000	0.00112	58.1[illegible]
343	2.34522	0.00211	58.071	344	2.33800	0.00141	57.901	345	2.33467	0.00167	57.822
346	2.33144	0.00113	57.746	347	2.33011	0.00073	57.714	348	2.32444	0.00207	57.581
349	2.32522	0.00211	57.599	350	2.32500	0.00206	57.594	351	2.32533	0.00224	57.602
352	2.32644	0.00181	57.628	353	2.32844	0.00113	57.675	354	1.98178	0.00067	49.423
355	1.97978	0.00067	49.375	356	1.97889	0.00060	49.353	357	1.97656	0.00133	49.297
358	1.97389	0.00136	49.233	359	1.97111	0.00093	49.166	360	1.97067	0.00071	49.156
361	1.96856	0.00073	49.105	362	1.96922	0.00067	49.121	363	1.96911	0.00070	49.118
364	1.96500	0.00173	49.020	365	1.96644	0.00151	49.054	366	1.96644	0.00174	49.054
367	1.94611	0.00154	48.566	368	1.94800	0.00112	48.611	369	1.94933	0.00050	48.643
370	1.94989	0.00060	48.656	371	1.95022	0.00063	48.664	372	1.95200	0.00087	48.707
373	1.95278	0.00109	48.726	374	1.95267	0.00100	48.723	375	1.95200	0.00200	48.707
376	1.95067	0.00087	48.675	377	1.95100	0.00067	48.683	378	1.95100	0.00071	48.683
379	1.95189	0.00078	48.704	380	1.97889	0.00060	49.353	381	1.97689	0.00154	49.305
382	1.97233	0.00122	49.196	383	1.97011	0.00060	49.142	384	1.96900	0.00071	49.116
385	1.96444	0.00151	49.006	386	1.96311	0.00105	48.974	387	1.96256	0.00101	48.961
388	1.96133	0.00071	48.932	389	1.96011	0.00060	48.902	390	1.95611	0.00170	48.806
391	1.95733	0.00141	48.835	392	1.95667	0.00141	48.819	393	1.95844	0.00073	48.862
394	1.95978	0.00067	48.894	395	1.96078	0.00067	48.916	396	1.96256	0.00101	48.961
397	1.96200	0.00071	48.948	398	1.96544	0.00174	49.030	399	1.96800	0.00087	49.092
400	1.96867	0.00087	49.108	401	1.96944	0.00053	49.126	402	1.96989	0.00070	49.137
403	1.97089	0.00078	49.161	404	1.97111	0.00078	49.166	405	1.97000	0.00071	49.140
406	2.32189	0.00127	57.520	407	2.32522	0.00222	57.599	408	2.32656	0.00235	57.630
409	2.32878	0.00083	57.683	410	2.32956	0.00113	57.701	411	2.33000	0.00100	57.712
412	2.33000	0.00100	57.712	413	2.32978	0.00053	57.707	414	2.33122	0.00109	57.741
415	2.33178	0.00120	57.754	416	2.33289	0.00196	57.780	417	2.33456	0.00230	57.819
418	2.33556	0.00240	57.843	419	1.43422	0.00044	36.094	420	1.43256	0.00053	36.053
421	1.43100	0.00000	36.015	422	1.43000	0.00000	35.990	423	1.42900	0.00000	35.965
424	1.42644	0.00053	35.902	425	1.42522	0.00063	35.872	426	1.42522	0.00053	35.872
427	1.42300	0.00000	35.817	428	1.42100	0.00000	35.768	429	1.42122	0.00044	35.773
430	1.42133	0.00050	35.776	431	1.42100	0.00000	35.768	432	1.96833	0.00100	49.100
433	1.96878	0.00097	49.110	434	1.96833	0.00071	49.100	435	1.96856	0.00053	49.105
436	1.96767	0.00132	49.084	437	1.96589	0.00176	49.041	438	1.96011	0.00060	48.902
439	1.96033	0.00071	48.907	440	1.96067	0.00071	48.915	441	1.96056	0.00073	48.913

TABLE F4 (continued)

442	1.96100	0.00100	48.923	443	1.96144	0.00073	48.934	444	1.96133	0.00087	48.932
445	1.94867	0.00050	48.027	446	1.95122	0.00109	48.686	447	1.95467	0.00150	48.771
448	1.95578	0.00067	48.570	449	1.95978	0.00067	48.894	450	1.96200	0.00100	48.946
451	1.96367	0.00132	48.968	452	1.96467	0.00141	49.012	453	1.96778	0.00097	49.086
454	1.96944	0.00053	49.126	455	1.96967	0.00071	49.132	456	1.96956	0.00053	49.129
457	1.96956	0.00053	49.129	458	1.95611	0.00247	48.806	459	1.95678	0.00217	48.822
460	1.95711	0.00242	48.830	461	1.95678	0.00244	48.822	462	1.95700	0.00265	48.827
463	1.95811	0.00169	48.854	464	1.95889	0.00165	48.873	465	1.95811	0.00203	48.854
466	1.95844	0.00133	48.862	467	1.95856	0.00124	48.865	468	1.95833	0.00173	48.859
469	1.95600	0.00187	48.851	470	1.95544	0.00246	48.790	471	1.99400	0.00206	49.716
472	1.99178	0.00148	49.663	473	1.98556	0.00151	49.585	474	1.98756	0.00167	49.561
475	1.96700	0.00187	49.548	476	1.98644	0.00194	49.535	477	1.98467	0.00229	49.492
478	1.98356	0.00207	49.465	479	1.98356	0.00194	49.465	480	1.97444	0.00230	49.246
481	1.97422	0.00222	49.241	482	1.97467	0.00224	49.252	483	1.97444	0.00267	49.246
484	2.02300	0.00173	50.411	485	2.02322	0.00192	50.417	486	2.02300	0.00173	50.411
487	2.02256	0.00142	50.401	488	2.02200	0.00173	50.387	489	2.02100	0.00122	50.363
490	2.02089	0.00136	50.361	491	2.02044	0.00133	50.350	492	2.02033	0.00132	50.347
493	2.01859	0.00117	50.313	494	2.01867	0.00150	50.307	495	2.01869	0.00130	50.313
496	2.01767	0.00173	50.283	497	1.66911	0.00078	41.857	498	1.66844	0.00073	41.841
499	1.66811	0.00078	41.833	500	1.66767	0.00122	41.822	501	1.66722	0.00109	41.811
502	1.66711	0.00136	41.809	503	1.66267	0.00112	41.700	504	1.66322	0.00063	41.714
505	1.66367	0.00141	41.725	506	1.66389	0.00117	41.730	507	1.66367	0.00122	41.725
508	1.66356	0.00101	41.722	509	1.66356	0.00124	41.722	510	2.03044	0.00101	50.590
511	2.03044	0.00133	50.590	512	2.03089	0.00117	50.600	513	2.03069	0.00117	50.600
514	2.03089	0.00117	50.600	515	2.03100	0.00122	50.603	516	2.03078	0.00097	50.598
517	2.03033	0.00112	50.567	518	2.03033	0.00112	50.587	519	2.03133	0.00141	50.611
520	2.03111	0.00105	50.606	521	2.03133	0.00141	50.611	522	2.03122	0.00130	50.608
523	1.94800	0.00112	48.611	524	1.94622	0.00083	48.616	525	1.94811	0.00127	48.614
526	1.94589	0.00190	48.560	527	1.94611	0.00176	48.566	528	1.94567	0.00194	48.555
529	1.94478	0.00205	48.533	530	1.94478	0.00205	48.535	531	1.94467	0.00200	48.531
532	1.94211	0.00127	48.469	533	1.94211	0.00127	48.469	534	1.94200	0.00132	48.467
535	1.94200	0.00122	48.467	536	2.08733	0.00218	51.950	537	2.08722	0.00233	51.947
538	2.08700	0.00224	51.942	539	2.08644	0.00270	51.929	540	2.08667	0.00240	51.934
541	2.08733	0.00240	51.950	542	2.08756	0.00251	51.955	543	2.08800	0.00200	51.966
544	4.45067	0.02535	105.462	545	4.45722	0.02465	105.603	546	4.46133	0.02539	105.692
547	4.46422	0.02547	105.754	548	4.46011	0.02532	105.665	549	1.73311	0.00127	43.416
550	1.73500	0.00158	43.461	551	1.73656	0.00201	43.499	552	1.73578	0.00083	43.553
553	1.73967	0.00050	43.575	554	1.73989	0.00060	43.580	555	1.74067	0.00071	43.599
556	1.99056	0.00124	49.633	557	1.99133	0.00173	49.652	558	1.99244	0.00159	49.679
559	1.99333	0.00206	49.700	560	1.99373	0.00217	49.711	561	1.99400	0.00240	49.716
562	1.99369	0.00220	49.713	563	1.68922	0.00067	42.348	564	1.68978	0.00067	42.361
565	1.69000	0.00087	42.356	566	1.69056	0.00068	42.380	567	1.69122	0.00097	42.396
568	2.26467	0.00283	56.167	569	2.26933	0.00173	56.278	570	2.27111	0.00183	56.320
571	2.27367	0.00292	56.360	572	2.27633	0.00260	56.443	573	2.27869	0.00220	56.504
574	2.28022	0.00186	56.535	575	2.28056	0.00207	56.543	576	2.56600	0.00326	63.251
577	2.56722	0.00346	63.280	578	2.56789	0.00322	63.296	579	2.56856	0.00290	63.311
580	2.56933	0.00300	63.329	581	2.57056	0.00265	63.358	582	2.57144	0.00290	63.379
583	2.57233	0.00324	63.399	584	2.46844	0.00270	60.969	585	2.46511	0.00285	60.891
586	2.46456	0.00283	60.876	587	2.46133	0.00312	60.802	588	2.46078	0.00295	60.769
589	3.38222	0.00620	81.954	590	3.38044	0.00550	81.914	591	3.37856	0.00575	81.872
592	3.37733	0.00566	81.844	593	3.37678	0.00578	81.832	594	3.37600	0.00574	81.814
595	4.70544	0.01162	110.919	596	4.70478	0.01167	110.904	597	4.70259	0.01076	110.864
598	4.70233	0.01117	110.852	599	2.95400	0.00472	72.228	600	2.95544	0.00482	72.261
601	2.95556	0.00436	72.266	602	2.95767	0.00436	72.312	603	2.96078	0.00459	72.383
604	2.96211	0.00454	72.414	605	2.46733	0.00354	60.943	606	2.46811	0.00293	60.951
607	2.46911	0.00289	60.965	608	2.46944	0.00279	60.992	609	2.46956	0.00266	60.995
610	2.46922	0.00254	60.967	611	2.96289	0.00431	72.432	612	2.96456	0.00453	72.470
613	2.96556	0.00461	72.493	614	2.96011	0.00459	72.366	615	2.96700	0.00436	72.526
616	2.96789	0.00454	72.546	617	3.39644	0.00561	82.274	618	3.39678	0.00565	82.262
619	3.39811	0.00573	82.312	620	3.39900	0.00608	82.332	621	3.40100	0.00579	82.377
622	3.40267	0.00577	82.414	623	4.71333	0.01164	111.067	624	4.72033	0.01126	111.236
625	4.72222	0.01149	111.276	626	4.72556	0.01163	111.347	627	4.72656	0.01133	111.389
628	4.72989	0.01106	111.439	629	2.70567	0.00442	66.501	630	2.70633	0.00456	66.517
631	2.70733	0.00439	66.540	632	2.70756	0.00456	66.545	633	2.70869	0.00443	66.576
634	2.70956	0.00413	66.591	635	2.89622	0.00239	70.947	636	2.90011	0.00190	70.991
637	2.90044	0.00188	70.998	638	2.90044	0.00161	70.996	639	2.90133	0.00250	71.019
640	2.90244	0.00260	71.044	641	3.19489	0.00310	77.722	642	3.19633	0.00263	77.755
643	3.19678	0.00295	77.765	644	3.19700	0.00263	77.770	645	3.19767	0.00269	77.785
646	3.19789	0.00262	77.790	647	3.66622	0.00307	88.306	648	3.66689	0.00372	88.321
649	3.66733	0.00400	88.330	650	3.66722	0.00356	88.328	651	3.66833	0.00324	88.353
652	3.66856	0.00343	88.358	653	4.22089	0.00446	100.594	654	4.22167	0.00464	100.510
655	4.22278	0.00409	100.535	656	4.22278	0.00444	100.535	657	4.22311	0.00443	100.542
658	4.22344	0.00413	100.549	659	6.10511	0.00909	139.974	660	6.10600	0.00901	139.992
661	6.10689	0.00852	140.010	662	6.10767	0.00849	140.026	663	6.10833	0.00822	140.039
664	6.11133	0.00863	140.100	665	1.57722	0.00244	39.611	666	1.57856	0.00161	39.644
667	1.57900	0.00166	39.655	668	1.58033	0.00112	39.687	669	1.58122	0.00179	39.709
670	1.72533	0.00377	43.226	671	1.72622	0.00335	43.246	672	1.72744	0.00357	43.278

TABLE F4 (continued)

673	1.72756	0.00328	43.281	674	1.72856	0.00336	43.305	675	2.09744	0.00675	52.192
676	2.09900	0.00686	52.229	677	2.10011	0.00704	52.255	678	2.10178	0.00719	52.295
679	1.69922	0.00083	42.591	680	1.69933	0.00067	42.594	681	1.69969	0.00076	42.607
682	1.70044	0.00113	42.621	683	1.70100	0.00132	42.634	684	1.70122	0.00097	42.640
685	1.93878	0.00164	48.369	686	1.94011	0.00145	48.421	687	1.94122	0.00156	48.448
688	1.94133	0.00158	48.451	689	1.94211	0.00176	48.469	690	1.94311	0.00169	48.493
691	2.24033	0.00212	55.591	692	2.24200	0.00212	55.630	693	2.24369	0.00280	55.675
694	2.24422	0.00286	55.683	695	2.24367	0.00287	55.670	696	2.24344	0.00276	55.604
697	2.55867	0.00346	63.080	698	2.56067	0.00339	63.127	699	2.56333	0.00371	63.169
700	2.56444	0.00371	63.215	701	2.56567	0.00367	63.244	702	2.56578	0.00399	63.246
703	1.68022	0.00067	42.128	704	1.65289	0.00093	42.193	705	1.66300	0.00050	42.176
706	1.68378	0.00083	42.215	707	1.65544	0.00151	42.256	708	1.66700	0.00112	42.293
709	1.90956	0.00101	47.686	710	1.91100	0.00112	47.720	711	1.91169	0.00136	47.742
712	1.91211	0.00145	47.747	713	1.91233	0.00141	47.753	714	1.91278	0.00130	47.703
715	2.23500	0.00274	55.464	716	2.24044	0.00765	55.593	717	2.23667	0.00265	55.504
718	2.23711	0.00242	55.514	719	2.23789	0.00262	55.533	720	2.23833	0.00216	55.543
721	1.68789	0.00145	42.315	722	1.68844	0.00101	42.329	723	1.68956	0.00073	42.336
724	1.69033	0.00071	42.375	725	1.69056	0.00068	42.380	726	1.69222	0.00109	42.421
727	1.91222	0.00120	47.750	728	1.91433	0.00200	47.801	729	1.91578	0.00217	47.835
730	1.91722	0.00192	47.870	731	1.91789	0.00232	47.686	732	1.91856	0.00201	47.902
733	2.23544	0.00292	55.475	734	2.23567	0.00260	55.480	735	2.23656	0.00279	55.501
736	2.23767	0.00269	55.527	737	2.23122	0.00249	55.541	738	2.23933	0.00235	55.567

TABLE F5

Raw Experimental Data

Thermocouple Wires Numbers 10 to 18

MILLIVOLTS READ IN FOR POSITIONS 10 TO 18 ARE

1	2.048	2.049	2.047	2.049	2.049	2.048	2.050	2.051	2.049
2	2.050	2.051	2.050	2.051	2.053	2.050	2.053	2.054	2.052
3	2.053	2.053	2.053	2.054	2.055	2.053	2.056	2.056	2.055
4	2.055	2.056	2.055	2.056	2.057	2.056	2.057	2.056	2.056
5	2.055	2.056	2.055	2.057	2.058	2.057	2.058	2.059	2.057
6	2.056	2.057	2.056	2.057	2.058	2.057	2.059	2.059	2.058
7	2.056	2.056	2.056	2.058	2.059	2.057	2.059	2.060	2.059
8	2.062	2.063	2.063	2.063	2.064	2.062	2.067	2.067	2.065
9	2.057	2.059	2.058	2.059	2.060	2.059	2.061	2.062	2.060
10	2.057	2.058	2.058	2.059	2.060	2.059	2.060	2.061	2.060
11	2.059	2.060	2.059	2.060	2.061	2.059	2.063	2.063	2.060
12	2.060	2.060	2.059	2.061	2.063	2.061	2.063	2.064	2.063
13	2.060	2.060	2.060	2.062	2.062	2.059	2.062	2.063	2.062
14	2.060	2.061	2.059	2.061	2.062	2.060	2.064	2.064	2.063
15	2.058	2.059	2.057	2.058	2.059	2.057	2.059	2.060	2.058
16	2.058	2.059	2.057	2.058	2.059	2.058	2.060	2.060	2.059
17	2.057	2.059	2.057	2.058	2.060	2.059	2.060	2.061	2.059
18	2.058	2.059	2.058	2.059	2.060	2.059	2.061	2.062	2.060
19	2.059	2.059	2.059	2.059	2.060	2.056	2.061	2.062	2.060
20	2.057	2.058	2.057	2.059	2.059	2.056	2.060	2.060	2.059
21	2.058	2.059	2.058	2.059	2.060	2.056	2.060	2.061	2.059
22	2.059	2.060	2.059	2.060	2.060	2.059	2.062	2.062	2.060
23	2.060	2.060	2.060	2.060	2.061	2.060	2.063	2.063	2.061
24	2.060	2.062	2.060	2.062	2.062	2.061	2.064	2.064	2.063
25	2.060	2.062	2.060	2.063	2.064	2.062	2.064	2.064	2.064
26	2.060	2.061	2.060	2.061	2.062	2.060	2.064	2.064	2.062
27	2.060	2.061	2.060	2.062	2.062	2.061	2.063	2.064	2.062
28	2.060	2.060	2.059	2.061	2.063	2.060	2.063	2.063	2.062
29	1.478	1.479	1.479	1.479	1.479	1.479	1.460	1.480	1.480
30	1.476	1.476	1.476	1.476	1.477	1.477	1.477	1.477	1.477
31	1.472	1.471	1.471	1.473	1.473	1.473	1.473	1.474	1.474
32	1.465	1.466	1.466	1.466	1.467	1.466	1.466	1.466	1.466
33	1.463	1.463	1.463	1.463	1.463	1.463	1.463	1.465	1.464
34	1.451	1.451	1.451	1.451	1.451	1.451	1.451	1.451	1.451
35	1.452	1.452	1.452	1.452	1.452	1.452	1.452	1.452	1.452
36	1.452	1.452	1.452	1.452	1.452	1.452	1.453	1.453	1.453
37	1.452	1.452	1.452	1.452	1.452	1.452	1.453	1.453	1.453
38	1.454	1.454	1.454	1.454	1.454	1.454	1.455	1.456	1.456
39	1.456	1.456	1.456	1.456	1.456	1.456	1.456	1.456	1.456
40	1.456	1.456	1.456	1.456	1.457	1.456	1.457	1.457	1.457
41	1.457	1.457	1.457	1.457	1.457	1.457	1.458	1.458	1.458
42	1.458	1.458	1.458	1.458	1.458	1.458	1.458	1.458	1.458
43	2.495	2.496	2.494	2.496	2.497	2.497	2.498	2.499	2.497
44	2.494	2.495	2.493	2.496	2.497	2.495	2.498	2.499	2.496
45	2.495	2.495	2.493	2.496	2.497	2.494	2.498	2.499	2.496
46	2.495	2.496	2.494	2.496	2.498	2.494	2.499	2.499	2.496
47	2.494	2.495	2.493	2.496	2.497	2.495	2.499	2.499	2.496
48	2.493	2.495	2.493	2.496	2.497	2.494	2.498	2.498	2.496
49	2.493	2.494	2.492	2.495	2.496	2.494	2.498	2.498	2.495
50	2.500	2.500	2.499	2.501	2.502	2.500	2.503	2.504	2.501
51	2.498	2.499	2.498	2.500	2.501	2.499	2.502	2.503	2.500
52	2.498	2.499	2.497	2.500	2.501	2.499	2.502	2.503	2.500
53	2.498	2.498	2.496	2.499	2.500	2.498	2.500	2.501	2.499
54	2.495	2.496	2.495	2.497	2.498	2.496	2.499	2.500	2.498
55	2.494	2.496	2.495	2.496	2.498	2.496	2.499	2.499	2.497
56	2.103	2.104	2.104	2.104	2.105	2.103	2.106	2.106	2.105
57	2.098	2.099	2.098	2.099	2.100	2.098	2.101	2.101	2.100
58	2.093	2.094	2.094	2.095	2.096	2.094	2.097	2.098	2.095
59	2.090	2.092	2.090	2.093	2.094	2.091	2.095	2.095	2.093
60	2.089	2.089	2.088	2.090	2.090	2.089	2.092	2.092	2.090
61	2.113	2.114	2.113	2.114	2.115	2.113	2.116	2.116	2.114
62	2.108	2.109	2.108	2.109	2.109	2.106	2.111	2.111	2.109
63	2.104	2.106	2.104	2.106	2.107	2.105	2.108	2.108	2.107
64	2.103	2.104	2.103	2.105	2.106	2.103	2.106	2.107	2.105
65	2.101	2.102	2.102	2.103	2.104	2.103	2.105	2.106	2.104
66	2.097	2.098	2.098	2.099	2.100	2.099	2.100	2.101	2.099
67	2.097	2.098	2.097	2.099	2.099	2.096	2.100	2.100	2.099
68	2.097	2.098	2.096	2.098	2.099	2.097	2.099	2.100	2.099
69	2.090	2.091	2.090	2.091	2.092	2.090	2.093	2.092	2.092
70	2.089	2.089	2.089	2.089	2.090	2.089	2.091	2.091	2.090
71	2.088	2.089	2.088	2.089	2.089	2.088	2.090	2.090	2.089
72	2.086	2.086	2.086	2.086	2.088	2.086	2.089	2.089	2.088

TABLE F5 (continued)

73	2.084	2.086	2.085	2.087	2.088	2.085	2.088	2.089	2.087
74	2.082	2.083	2.082	2.083	2.083	2.083	2.085	2.085	2.083
75	2.078	2.079	2.078	2.079	2.080	2.079	2.080	2.080	2.079
76	2.078	2.079	2.078	2.080	2.080	2.079	2.081	2.082	2.080
77	2.078	2.079	2.079	2.079	2.080	2.079	2.080	2.081	2.080
78	2.071	2.072	2.072	2.073	2.073	2.072	2.074	2.075	2.073
79	2.074	2.075	2.073	2.076	2.077	2.075	2.078	2.078	2.076
80	2.076	2.077	2.076	2.077	2.078	2.076	2.079	2.079	2.077
81	2.089	2.090	2.088	2.090	2.090	2.080	2.091	2.091	2.089
82	2.076	2.077	2.074	2.078	2.078	2.075	2.079	2.079	2.077
83	2.081	2.082	2.081	2.083	2.084	2.081	2.086	2.086	2.083
84	2.079	2.079	2.078	2.080	2.080	2.079	2.081	2.081	2.080
85	2.073	2.073	2.072	2.075	2.075	2.072	2.078	2.077	2.075
86	2.071	2.073	2.071	2.074	2.075	2.072	2.076	2.077	2.073
87	2.072	2.073	2.071	2.074	2.075	2.071	2.076	2.076	2.073
88	2.099	2.099	2.097	2.099	2.100	2.097	2.100	2.100	2.099
89	2.087	2.088	2.085	2.088	2.089	2.087	2.090	2.090	2.089
90	2.080	2.080	2.080	2.081	2.081	2.080	2.083	2.083	2.081
91	2.079	2.080	2.079	2.080	2.080	2.079	2.081	2.081	2.080
92	2.079	2.080	2.078	2.080	2.080	2.079	2.081	2.081	2.080
93	2.082	2.083	2.081	2.085	2.085	2.083	2.087	2.087	2.084
94	1.459	1.459	1.459	1.459	1.459	1.459	1.459	1.459	1.459
95	1.463	1.464	1.463	1.464	1.464	1.464	1.466	1.466	1.465
96	1.463	1.463	1.463	1.463	1.464	1.463	1.465	1.465	1.464
97	1.470	1.470	1.470	1.469	1.469	1.470	1.471	1.470	1.470
98	1.470	1.470	1.470	1.470	1.470	1.469	1.470	1.470	1.470
99	1.468	1.468	1.468	1.468	1.469	1.469	1.469	1.469	1.469
100	1.468	1.468	1.468	1.468	1.469	1.466	1.469	1.469	1.468
101	1.460	1.460	1.459	1.460	1.460	1.459	1.460	1.460	1.460
102	1.467	1.467	1.467	1.467	1.467	1.467	1.467	1.467	1.467
103	1.468	1.463	1.466	1.467	1.468	1.467	1.468	1.468	1.468
104	1.468	1.468	1.466	1.467	1.468	1.466	1.468	1.468	1.468
105	1.466	1.466	1.464	1.465	1.467	1.467	1.467	1.467	1.467
106	1.462	1.462	1.462	1.462	1.463	1.464	1.465	1.465	1.465
107	2.543	2.544	2.541	2.545	2.547	2.542	2.548	2.549	2.544
108	2.535	2.537	2.532	2.538	2.539	2.535	2.540	2.540	2.538
109	2.529	2.530	2.525	2.530	2.530	2.526	2.531	2.532	2.530
110	2.549	2.549	2.547	2.550	2.549	2.546	2.551	2.551	2.549
111	2.535	2.537	2.531	2.538	2.539	2.532	2.539	2.539	2.537
112	2.529	2.529	2.526	2.530	2.530	2.529	2.531	2.533	2.530
113	2.523	2.524	2.521	2.526	2.528	2.522	2.529	2.529	2.526
114	2.519	2.519	2.517	2.520	2.521	2.516	2.522	2.523	2.520
115	2.514	2.516	2.511	2.518	2.519	2.514	2.520	2.520	2.517
116	2.510	2.511	2.510	2.511	2.513	2.510	2.514	2.514	2.511
117	2.509	2.509	2.508	2.509	2.511	2.506	2.512	2.513	2.510
118	2.500	2.501	2.500	2.502	2.503	2.500	2.505	2.507	2.501
119	2.499	2.500	2.499	2.501	2.502	2.499	2.503	2.504	2.501
120	2.117	2.119	2.114	2.119	2.119	2.118	2.119	2.119	2.118
121	2.111	2.111	2.110	2.113	2.113	2.111	2.115	2.115	2.112
122	2.107	2.107	2.105	2.109	2.109	2.106	2.109	2.109	2.108
123	2.100	2.101	2.100	2.102	2.102	2.100	2.104	2.105	2.102
124	2.096	2.097	2.093	2.098	2.099	2.095	2.099	2.099	2.097
125	2.090	2.091	2.090	2.093	2.094	2.091	2.095	2.095	2.092
126	2.090	2.090	2.089	2.090	2.091	2.090	2.092	2.092	2.091
127	2.090	2.090	2.090	2.091	2.092	2.090	2.094	2.094	2.091
128	2.114	2.115	2.112	2.116	2.118	2.113	2.119	2.119	2.115
129	2.109	2.110	2.108	2.110	2.110	2.109	2.111	2.111	2.110
130	2.107	2.108	2.104	2.108	2.109	2.107	2.109	2.109	2.109
131	2.101	2.102	2.100	2.102	2.103	2.101	2.104	2.104	2.102
132	2.094	2.095	2.093	2.098	2.098	2.094	2.099	2.099	2.097
133	2.109	2.110	2.109	2.110	2.111	2.109	2.111	2.111	2.110
134	2.104	2.106	2.102	2.106	2.108	2.104	2.108	2.109	2.107
135	2.101	2.102	2.100	2.103	2.104	2.101	2.106	2.106	2.102
136	2.110	2.110	2.109	2.110	2.110	2.110	2.111	2.112	2.110
137	2.102	2.103	2.101	2.104	2.106	2.101	2.108	2.108	2.104
138	2.087	2.087	2.083	2.088	2.089	2.087	2.089	2.089	2.088
139	2.111	2.112	2.110	2.111	2.112	2.110	2.114	2.114	2.111
140	2.104	2.106	2.102	2.106	2.107	2.103	2.108	2.108	2.106
141	2.099	2.099	2.098	2.100	2.100	2.099	2.100	2.101	2.100
142	2.094	2.094	2.091	2.095	2.096	2.091	2.097	2.097	2.095
143	2.089	2.089	2.087	2.090	2.090	2.086	2.090	2.090	2.089
144	2.082	2.084	2.081	2.086	2.087	2.083	2.088	2.089	2.086
145	2.083	2.084	2.081	2.085	2.085	2.082	2.087	2.088	2.084
146	2.089	2.089	2.087	2.089	2.089	2.086	2.090	2.090	2.089
147	2.085	2.087	2.084	2.088	2.089	2.085	2.089	2.089	2.087
148	2.080	2.080	2.079	2.081	2.081	2.080	2.082	2.083	2.081
149	2.080	2.080	2.079	2.080	2.081	2.080	2.082	2.082	2.081

TABLE F5 (continued)

150	2.079	2.079	2.077	2.080	2.080	2.079	2.081	2.081	2.080
151	2.077	2.078	2.076	2.079	2.079	2.078	2.080	2.080	2.079
152	2.076	2.076	2.075	2.078	2.079	2.076	2.079	2.080	2.079
153	2.075	2.076	2.074	2.077	2.078	2.075	2.079	2.079	2.078
154	2.071	2.072	2.071	2.073	2.075	2.071	2.076	2.077	2.073
155	2.072	2.073	2.071	2.073	2.075	2.071	2.077	2.078	2.074
156	2.071	2.071	2.070	2.073	2.074	2.071	2.075	2.075	2.073
157	2.089	2.089	2.088	2.090	2.090	2.089	2.091	2.091	2.090
158	2.083	2.084	2.081	2.085	2.086	2.082	2.087	2.087	2.085
159	2.103	2.103	2.100	2.103	2.104	2.101	2.105	2.105	2.102
160	2.099	2.099	2.096	2.099	2.099	2.097	2.100	2.100	2.099
161	2.092	2.092	2.090	2.094	2.094	2.091	2.095	2.097	2.093
162	2.089	2.089	2.088	2.090	2.090	2.090	2.091	2.091	2.090
163	2.087	2.087	2.084	2.088	2.088	2.085	2.089	2.089	2.088
164	2.082	2.082	2.081	2.084	2.085	2.081	2.088	2.087	2.083
165	2.080	2.081	2.079	2.081	2.082	2.080	2.082	2.083	2.081
166	2.074	2.075	2.071	2.076	2.077	2.073	2.078	2.079	2.075
167	2.072	2.073	2.071	2.074	2.074	2.071	2.076	2.076	2.073
168	2.069	2.069	2.067	2.070	2.070	2.069	2.071	2.071	2.069
169	2.069	2.069	2.068	2.070	2.070	2.069	2.071	2.071	2.069
170	2.071	2.072	2.070	2.072	2.073	2.071	2.075	2.075	2.072
171	2.072	2.073	2.070	2.072	2.073	2.071	2.075	2.075	2.072
172	1.450	1.450	1.450	1.450	1.450	1.450	1.450	1.450	1.450
173	1.449	1.449	1.449	1.449	1.449	1.449	1.449	1.449	1.449
174	1.444	1.444	1.444	1.445	1.445	1.444	1.445	1.446	1.446
175	1.443	1.443	1.443	1.443	1.443	1.443	1.444	1.444	1.444
176	1.441	1.441	1.441	1.441	1.441	1.441	1.442	1.442	1.442
177	1.440	1.440	1.440	1.440	1.440	1.440	1.441	1.441	1.440
178	1.440	1.440	1.440	1.440	1.440	1.440	1.440	1.440	1.440
179	1.440	1.440	1.440	1.440	1.440	1.440	1.441	1.441	1.440
180	1.440	1.440	1.440	1.440	1.441	1.441	1.441	1.441	1.441
181	1.441	1.441	1.441	1.441	1.441	1.441	1.442	1.442	1.442
182	1.441	1.441	1.440	1.441	1.441	1.440	1.442	1.442	1.441
183	1.441	1.441	1.440	1.441	1.441	1.441	1.442	1.442	1.442
184	1.441	1.441	1.441	1.441	1.441	1.441	1.442	1.442	1.442
185	2.495	2.496	2.492	2.498	2.498	2.494	2.499	2.499	2.498
186	2.500	2.501	2.498	2.502	2.503	2.499	2.505	2.506	2.501
187	2.499	2.500	2.498	2.502	2.502	2.499	2.502	2.504	2.500
188	2.522	2.522	2.519	2.524	2.524	2.520	2.527	2.528	2.522
189	2.507	2.508	2.503	2.509	2.509	2.504	2.510	2.510	2.508
190	2.551	2.552	2.549	2.553	2.553	2.549	2.556	2.557	2.551
191	2.539	2.539	2.535	2.540	2.540	2.537	2.541	2.542	2.539
192	2.530	2.530	2.527	2.531	2.532	2.529	2.534	2.534	2.530
193	2.510	2.512	2.509	2.513	2.514	2.510	2.516	2.516	2.511
194	2.509	2.509	2.509	2.505	2.510	2.506	2.512	2.511	2.509
195	2.503	2.503	2.500	2.505	2.507	2.501	2.508	2.508	2.503
196	2.500	2.501	2.499	2.502	2.503	2.499	2.505	2.506	2.501
197	2.502	2.503	2.499	2.503	2.505	2.500	2.508	2.508	2.502
198	2.099	2.099	2.097	2.099	2.099	2.097	2.099	2.099	2.099
199	2.093	2.093	2.091	2.094	2.095	2.091	2.097	2.097	2.094
200	2.090	2.090	2.089	2.091	2.091	2.089	2.092	2.092	2.090
201	2.088	2.089	2.087	2.089	2.089	2.087	2.090	2.090	2.089
202	2.087	2.086	2.083	2.088	2.088	2.084	2.089	2.089	2.086
203	2.082	2.083	2.080	2.084	2.084	2.081	2.087	2.087	2.083
204	2.081	2.083	2.080	2.083	2.084	2.081	2.086	2.086	2.082
205	2.081	2.081	2.079	2.081	2.082	2.080	2.083	2.084	2.081
206	2.080	2.080	2.079	2.081	2.081	2.080	2.082	2.082	2.081
207	2.079	2.079	2.077	2.079	2.079	2.078	2.080	2.080	2.079
208	2.079	2.079	2.077	2.079	2.080	2.078	2.080	2.080	2.079
209	2.078	2.079	2.075	2.079	2.079	2.077	2.080	2.080	2.079
210	2.071	2.072	2.070	2.073	2.074	2.072	2.075	2.075	2.073
211	2.078	2.078	2.074	2.079	2.079	2.077	2.080	2.080	2.078
212	2.079	2.079	2.077	2.079	2.080	2.078	2.080	2.080	2.079
213	2.078	2.079	2.075	2.079	2.079	2.077	2.080	2.080	2.079
214	2.078	2.079	2.075	2.079	2.079	2.077	2.080	2.080	2.079
215	2.078	2.078	2.076	2.079	2.079	2.076	2.080	2.080	2.079
216	2.099	2.099	2.098	2.099	2.099	2.099	2.099	2.099	2.099
217	2.095	2.094	2.092	2.097	2.097	2.093	2.098	2.099	2.095
218	2.091	2.091	2.089	2.092	2.092	2.090	2.094	2.094	2.091
219	2.089	2.089	2.087	2.090	2.090	2.086	2.090	2.091	2.089
220	2.085	2.086	2.083	2.087	2.088	2.084	2.089	2.089	2.087
221	2.083	2.084	2.082	2.085	2.087	2.083	2.088	2.088	2.084
222	2.081	2.082	2.080	2.082	2.083	2.080	2.084	2.084	2.082
223	2.078	2.079	2.076	2.079	2.079	2.077	2.080	2.080	2.079
224	2.071	2.071	2.070	2.072	2.072	2.070	2.073	2.073	2.071
225	2.071	2.071	2.069	2.072	2.072	2.070	2.073	2.073	2.072
226	2.069	2.070	2.068	2.070	2.071	2.069	2.072	2.071	2.070

TABLE F5 (continued)

227	2.071	2.071	2.070	2.072	2.073	2.070	2.073	2.074	2.072
228	2.071	2.072	2.070	2.073	2.073	2.071	2.075	2.075	2.073
229	2.067	2.067	2.064	2.068	2.068	2.065	2.069	2.069	2.068
230	2.068	2.068	2.065	2.069	2.070	2.067	2.070	2.070	2.069
231	2.068	2.068	2.067	2.069	2.069	2.066	2.070	2.070	2.069
232	2.072	2.072	2.070	2.073	2.073	2.071	2.075	2.075	2.073
233	2.073	2.073	2.071	2.074	2.074	2.072	2.077	2.077	2.074
234	2.073	2.074	2.072	2.075	2.077	2.073	2.078	2.078	2.075
235	2.073	2.073	2.071	2.074	2.074	2.072	2.077	2.077	2.074
236	2.074	2.074	2.072	2.076	2.077	2.073	2.079	2.078	2.076
237	2.072	2.073	2.070	2.073	2.073	2.071	2.075	2.075	2.072
238	2.069	2.069	2.067	2.070	2.070	2.068	2.071	2.071	2.069
239	2.067	2.067	2.064	2.068	2.069	2.066	2.069	2.069	2.068
240	2.066	2.066	2.062	2.066	2.067	2.063	2.069	2.069	2.065
241	2.071	2.071	2.069	2.072	2.073	2.070	2.073	2.074	2.071
242	2.071	2.071	2.070	2.073	2.073	2.070	2.073	2.074	2.072
243	2.071	2.072	2.070	2.072	2.073	2.070	2.073	2.073	2.072
244	2.071	2.071	2.070	2.072	2.072	2.070	2.073	2.072	2.072
245	2.071	2.071	2.070	2.072	2.073	2.070	2.074	2.074	2.072
246	2.071	2.071	2.070	2.072	2.073	2.071	2.074	2.074	2.072
247	2.071	2.072	2.070	2.073	2.073	2.071	2.074	2.075	2.072
248	2.072	2.073	2.071	2.073	2.074	2.072	2.076	2.077	2.073
249	2.072	2.073	2.071	2.073	2.073	2.071	2.075	2.075	2.073
250	1.443	1.443	1.443	1.444	1.444	1.444	1.444	1.444	1.443
251	1.442	1.442	1.442	1.442	1.443	1.443	1.444	1.444	1.443
252	1.442	1.442	1.442	1.442	1.443	1.442	1.443	1.443	1.443
253	1.442	1.442	1.442	1.442	1.442	1.442	1.442	1.442	1.442
254	1.441	1.441	1.440	1.441	1.441	1.442	1.441	1.442	1.442
255	1.440	1.440	1.440	1.440	1.440	1.440	1.440	1.440	1.440
256	1.440	1.440	1.439	1.440	1.440	1.440	1.440	1.440	1.440
257	1.440	1.440	1.440	1.440	1.440	1.440	1.440	1.440	1.440
258	1.439	1.439	1.439	1.440	1.440	1.440	1.440	1.440	1.440
259	1.438	1.438	1.438	1.438	1.438	1.438	1.438	1.439	1.439
260	1.439	1.439	1.438	1.439	1.439	1.439	1.439	1.439	1.439
261	1.439	1.439	1.438	1.439	1.439	1.439	1.439	1.439	1.439
262	1.439	1.439	1.439	1.439	1.439	1.439	1.439	1.439	1.439
263	2.504	2.505	2.503	2.508	2.509	2.504	2.510	2.510	2.506
264	2.508	2.508	2.503	2.509	2.510	2.506	2.510	2.511	2.509
265	2.510	2.511	2.509	2.512	2.513	2.509	2.515	2.515	2.512
266	2.511	2.512	2.509	2.513	2.514	2.510	2.517	2.517	2.512
267	2.512	2.512	2.510	2.513	2.514	2.510	2.517	2.518	2.513
268	2.513	2.513	2.510	2.514	2.515	2.511	2.518	2.518	2.514
269	2.512	2.513	2.510	2.514	2.514	2.510	2.518	2.518	2.514
270	2.515	2.515	2.512	2.517	2.518	2.513	2.519	2.519	2.517
271	2.515	2.517	2.512	2.517	2.519	2.513	2.520	2.520	2.518
272	2.515	2.516	2.512	2.518	2.519	2.513	2.520	2.520	2.517
273	2.515	2.517	2.512	2.518	2.519	2.513	2.520	2.520	2.516
274	2.513	2.513	2.510	2.515	2.516	2.512	2.519	2.519	2.514
275	2.513	2.513	2.511	2.517	2.517	2.512	2.519	2.519	2.514
276	2.117	2.117	2.114	2.117	2.118	2.114	2.119	2.119	2.117
277	2.112	2.111	2.110	2.113	2.113	2.111	2.114	2.114	2.112
278	2.111	2.112	2.110	2.113	2.113	2.110	2.114	2.114	2.112
279	2.110	2.110	2.109	2.110	2.110	2.109	2.112	2.112	2.110
280	2.109	2.109	2.107	2.109	2.110	2.106	2.111	2.111	2.109
281	2.108	2.108	2.104	2.109	2.109	2.105	2.110	2.110	2.108
282	2.105	2.104	2.102	2.106	2.105	2.103	2.107	2.108	2.105
283	2.100	2.100	2.100	2.100	2.100	2.100	2.101	2.101	2.100
284	2.100	2.100	2.100	2.100	2.100	2.100	2.101	2.101	2.100
285	2.100	2.100	2.100	2.100	2.101	2.100	2.101	2.101	2.100
286	2.100	2.101	2.100	2.102	2.102	2.100	2.103	2.104	2.101
287	2.102	2.102	2.100	2.103	2.103	2.100	2.106	2.106	2.103
288	2.101	2.102	2.100	2.103	2.104	2.101	2.106	2.106	2.103
289	2.100	2.100	2.100	2.100	2.101	2.100	2.101	2.102	2.100
290	2.100	2.100	2.100	2.102	2.102	2.100	2.103	2.103	2.101
291	2.100	2.100	2.100	2.101	2.101	2.100	2.102	2.103	2.101
292	2.100	2.100	2.100	2.100	2.100	2.100	2.102	2.102	2.100
293	2.124	2.124	2.121	2.125	2.126	2.122	2.127	2.127	2.123
294	2.120	2.120	2.119	2.120	2.120	2.119	2.122	2.122	2.120
295	2.116	2.116	2.114	2.118	2.118	2.114	2.119	2.119	2.117
296	2.111	2.112	2.110	2.112	2.112	2.111	2.114	2.114	2.112
297	2.109	2.109	2.108	2.109	2.110	2.108	2.111	2.111	2.109
298	2.100	2.100	2.100	2.100	2.100	2.100	2.101	2.101	2.100
299	2.098	2.098	2.096	2.099	2.099	2.097	2.099	2.099	2.099
300	2.096	2.098	2.094	2.098	2.099	2.095	2.099	2.099	2.098
301	2.097	2.097	2.093	2.097	2.098	2.094	2.099	2.099	2.097
302	2.089	2.089	2.087	2.090	2.090	2.088	2.091	2.091	2.090
303	2.089	2.089	2.088	2.090	2.090	2.088	2.091	2.091	2.090

TABLE F5 (continued)

304	2.084	2.085	2.083	2.087	2.087	2.084	2.088	2.088	2.086
305	2.084	2.085	2.083	2.087	2.088	2.083	2.089	2.089	2.087
306	2.085	2.085	2.082	2.087	2.088	2.083	2.088	2.088	2.085
307	2.078	2.079	2.077	2.079	2.079	2.076	2.080	2.080	2.079
308	2.078	2.078	2.077	2.079	2.079	2.078	2.080	2.080	2.079
309	2.079	2.079	2.077	2.079	2.080	2.078	2.080	2.080	2.079
310	2.079	2.079	2.078	2.080	2.080	2.079	2.081	2.081	2.080
311	2.080	2.080	2.079	2.081	2.081	2.079	2.083	2.083	2.081
312	2.080	2.080	2.079	2.081	2.081	2.080	2.083	2.083	2.081
313	2.080	2.080	2.079	2.081	2.081	2.080	2.082	2.082	2.080
314	2.080	2.080	2.079	2.080	2.081	2.079	2.082	2.082	2.080
315	2.042	2.042	2.041	2.043	2.044	2.042	2.045	2.046	2.044
316	2.043	2.044	2.043	2.044	2.045	2.043	2.048	2.047	2.045
317	2.045	2.047	2.044	2.046	2.048	2.045	2.048	2.048	2.048
318	2.046	2.047	2.046	2.048	2.048	2.047	2.049	2.049	2.048
319	2.047	2.048	2.046	2.049	2.049	2.048	2.050	2.049	2.049
320	2.047	2.048	2.048	2.049	2.049	2.048	2.050	2.050	2.049
321	2.048	2.049	2.048	2.049	2.049	2.048	2.050	2.050	2.049
322	2.049	2.050	2.049	2.050	2.051	2.050	2.052	2.053	2.051
323	2.049	2.050	2.049	2.050	2.051	2.050	2.052	2.052	2.051
324	2.049	2.050	2.049	2.051	2.051	2.050	2.052	2.053	2.051
325	2.050	2.050	2.049	2.051	2.051	2.050	2.052	2.054	2.051
326	2.053	2.054	2.053	2.054	2.056	2.053	2.057	2.057	2.054
327	2.057	2.057	2.054	2.058	2.058	2.056	2.059	2.059	2.058
328	1.445	1.445	1.445	1.445	1.446	1.444	1.446	1.446	1.446
329	1.446	1.446	1.446	1.446	1.446	1.446	1.446	1.446	1.446
330	1.444	1.444	1.444	1.444	1.445	1.444	1.446	1.446	1.446
331	1.444	1.444	1.444	1.444	1.445	1.445	1.445	1.445	1.445
332	1.444	1.444	1.444	1.444	1.445	1.445	1.445	1.445	1.445
333	1.444	1.444	1.444	1.444	1.445	1.445	1.445	1.445	1.444
334	1.444	1.444	1.444	1.444	1.444	1.444	1.445	1.445	1.445
335	1.443	1.443	1.443	1.443	1.443	1.443	1.443	1.443	1.443
336	1.443	1.443	1.443	1.443	1.443	1.443	1.444	1.444	1.444
337	1.443	1.443	1.443	1.443	1.443	1.443	1.445	1.445	1.445
338	1.443	1.443	1.442	1.443	1.443	1.443	1.443	1.443	1.443
339	1.443	1.443	1.443	1.443	1.444	1.443	1.444	1.444	1.444
340	1.444	1.444	1.444	1.444	1.444	1.444	1.444	1.444	1.445
341	2.502	2.503	2.501	2.503	2.504	2.501	2.506	2.507	2.502
342	2.493	2.494	2.492	2.494	2.496	2.492	2.498	2.498	2.495
343	2.488	2.489	2.488	2.490	2.490	2.489	2.491	2.492	2.490
344	2.480	2.480	2.479	2.480	2.481	2.479	2.483	2.484	2.481
345	2.477	2.479	2.477	2.479	2.479	2.478	2.480	2.481	2.479
346	2.473	2.474	2.473	2.476	2.478	2.474	2.479	2.479	2.478
347	2.472	2.473	2.471	2.474	2.476	2.472	2.478	2.479	2.474
348	2.468	2.469	2.467	2.469	2.470	2.468	2.471	2.471	2.470
349	2.468	2.469	2.467	2.469	2.470	2.469	2.471	2.472	2.470
350	2.468	2.469	2.468	2.469	2.470	2.469	2.471	2.472	2.470
351	2.468	2.469	2.467	2.469	2.470	2.469	2.471	2.472	2.470
352	2.469	2.469	2.468	2.470	2.471	2.470	2.472	2.473	2.470
353	2.470	2.470	2.469	2.471	2.472	2.470	2.474	2.474	2.472
354	2.078	2.079	2.077	2.079	2.079	2.078	2.080	2.080	2.079
355	2.073	2.074	2.073	2.075	2.076	2.074	2.078	2.078	2.076
356	2.071	2.072	2.071	2.073	2.073	2.072	2.074	2.075	2.073
357	2.070	2.070	2.070	2.070	2.070	2.070	2.071	2.071	2.071
358	2.069	2.069	2.069	2.070	2.070	2.069	2.070	2.070	2.070
359	2.066	2.067	2.065	2.068	2.068	2.067	2.069	2.069	2.068
360	2.066	2.066	2.066	2.067	2.068	2.067	2.069	2.069	2.068
361	2.061	2.061	2.061	2.061	2.062	2.061	2.064	2.064	2.062
362	2.062	2.063	2.061	2.063	2.064	2.062	2.066	2.067	2.064
363	2.061	2.062	2.061	2.062	2.063	2.061	2.064	2.066	2.063
364	2.059	2.059	2.059	2.060	2.060	2.059	2.061	2.061	2.060
365	2.059	2.060	2.060	2.060	2.061	2.060	2.061	2.062	2.060
366	2.059	2.060	2.060	2.061	2.061	2.060	2.062	2.062	2.061
367	2.039	2.040	2.039	2.040	2.041	2.039	2.041	2.041	2.040
368	2.040	2.041	2.040	2.041	2.042	2.041	2.043	2.044	2.042
369	2.041	2.042	2.041	2.042	2.044	2.042	2.044	2.045	2.043
370	2.042	2.043	2.042	2.044	2.045	2.044	2.047	2.048	2.045
371	2.043	2.044	2.043	2.045	2.047	2.044	2.049	2.049	2.047
372	2.048	2.048	2.047	2.049	2.049	2.048	2.049	2.049	2.049
373	2.048	2.048	2.047	2.049	2.049	2.048	2.049	2.050	2.049
374	2.048	2.048	2.047	2.048	2.049	2.048	2.050	2.049	2.048
375	2.046	2.048	2.045	2.048	2.048	2.047	2.049	2.049	2.048
376	2.043	2.045	2.044	2.045	2.046	2.044	2.048	2.046	2.046
377	2.045	2.047	2.045	2.047	2.048	2.046	2.049	2.049	2.046
378	2.044	2.047	2.045	2.047	2.048	2.044	2.049	2.049	2.047
379	2.046	2.048	2.047	2.048	2.049	2.047	2.049	2.049	2.048
380	2.070	2.071	2.070	2.071	2.071	2.070	2.072	2.072	2.071

TABLE F5 (continued)

381	2.068	2.069	2.068	2.069	2.069	2.068	2.070	2.070	2.069
382	2.063	2.064	2.063	2.065	2.066	2.063	2.067	2.068	2.065
383	2.061	2.062	2.060	2.062	2.062	2.061	2.063	2.063	2.061
384	2.059	2.060	2.059	2.060	2.061	2.059	2.061	2.061	2.060
385	2.054	2.057	2.053	2.057	2.057	2.054	2.059	2.059	2.058
386	2.053	2.054	2.052	2.054	2.056	2.053	2.058	2.058	2.056
387	2.052	2.053	2.052	2.054	2.055	2.053	2.057	2.057	2.054
388	2.051	2.051	2.051	2.052	2.053	2.051	2.054	2.054	2.053
389	2.050	2.051	2.050	2.050	2.051	2.051	2.053	2.053	2.051
390	2.044	2.047	2.044	2.048	2.048	2.044	2.049	2.049	2.048
391	2.045	2.047	2.045	2.048	2.048	2.045	2.049	2.049	2.048
392	2.046	2.047	2.044	2.046	2.048	2.045	2.049	2.049	2.048
393	2.051	2.051	2.051	2.051	2.052	2.051	2.053	2.054	2.052
394	2.052	2.053	2.052	2.053	2.054	2.053	2.057	2.057	2.054
395	2.054	2.056	2.054	2.056	2.057	2.055	2.059	2.059	2.057
396	2.057	2.059	2.057	2.058	2.059	2.058	2.060	2.060	2.059
397	2.058	2.058	2.057	2.059	2.059	2.058	2.060	2.060	2.059
398	2.060	2.061	2.059	2.060	2.061	2.060	2.063	2.062	2.061
399	2.061	2.061	2.061	2.061	2.062	2.061	2.063	2.063	2.062
400	2.061	2.062	2.061	2.062	2.063	2.061	2.064	2.066	2.062
401	2.063	2.064	2.062	2.063	2.065	2.063	2.067	2.067	2.064
402	2.064	2.065	2.064	2.065	2.067	2.063	2.067	2.068	2.066
403	2.067	2.067	2.066	2.068	2.068	2.067	2.069	2.069	2.068
404	2.067	2.068	2.065	2.068	2.068	2.067	2.069	2.069	2.068
405	2.063	2.064	2.063	2.065	2.067	2.064	2.068	2.066	2.068
406	2.472	2.473	2.472	2.474	2.475	2.472	2.478	2.478	2.474
407	2.474	2.478	2.474	2.478	2.479	2.477	2.480	2.480	2.479
408	2.477	2.479	2.478	2.479	2.480	2.478	2.481	2.481	2.480
409	2.479	2.479	2.478	2.480	2.481	2.479	2.482	2.482	2.481
410	2.480	2.481	2.479	2.481	2.481	2.480	2.483	2.485	2.482
411	2.480	2.481	2.480	2.481	2.483	2.480	2.484	2.487	2.483
412	2.480	2.481	2.480	2.481	2.483	2.481	2.485	2.487	2.483
413	2.480	2.481	2.480	2.481	2.482	2.480	2.485	2.487	2.483
414	2.481	2.482	2.481	2.483	2.486	2.482	2.488	2.489	2.487
415	2.482	2.484	2.482	2.486	2.488	2.483	2.489	2.489	2.487
416	2.484	2.486	2.483	2.487	2.489	2.484	2.490	2.490	2.488
417	2.486	2.488	2.484	2.488	2.489	2.487	2.490	2.491	2.489
418	2.488	2.489	2.487	2.489	2.490	2.488	2.491	2.491	2.490
419	1.458	1.458	1.457	1.457	1.457	1.457	1.457	1.457	1.457
420	1.453	1.453	1.453	1.453	1.454	1.454	1.455	1.455	1.453
421	1.452	1.452	1.452	1.452	1.452	1.452	1.452	1.452	1.452
422	1.451	1.451	1.451	1.451	1.451	1.452	1.451	1.451	1.451
423	1.450	1.450	1.450	1.450	1.450	1.450	1.450	1.450	1.450
424	1.447	1.447	1.447	1.447	1.448	1.448	1.448	1.448	1.448
425	1.447	1.448	1.448	1.448	1.448	1.448	1.449	1.449	1.449
426	1.447	1.447	1.447	1.447	1.448	1.448	1.448	1.448	1.448
427	1.444	1.444	1.444	1.444	1.445	1.445	1.445	1.445	1.445
428	1.441	1.441	1.441	1.441	1.441	1.442	1.442	1.442	1.442
429	1.442	1.442	1.442	1.442	1.442	1.442	1.442	1.442	1.442
430	1.442	1.442	1.442	1.442	1.442	1.442	1.442	1.442	1.442
431	1.441	1.441	1.441	1.441	1.442	1.442	1.442	1.442	1.442
432	2.060	2.061	2.060	2.061	2.061	2.061	2.062	2.063	2.062
433	2.061	2.061	2.060	2.061	2.061	2.060	2.062	2.062	2.062
434	2.061	2.061	2.060	2.061	2.061	2.061	2.063	2.063	2.062
435	2.060	2.061	2.060	2.061	2.061	2.060	2.062	2.062	2.061
436	2.060	2.060	2.060	2.060	2.061	2.060	2.062	2.062	2.061
437	2.059	2.059	2.059	2.060	2.060	2.059	2.061	2.061	2.060
438	2.052	2.052	2.052	2.053	2.053	2.052	2.056	2.056	2.054
439	2.052	2.053	2.052	2.053	2.054	2.053	2.058	2.056	2.055
440	2.053	2.053	2.052	2.054	2.054	2.052	2.058	2.058	2.055
441	2.052	2.053	2.051	2.053	2.055	2.053	2.057	2.057	2.055
442	2.054	2.054	2.053	2.055	2.055	2.053	2.058	2.058	2.057
443	2.054	2.055	2.053	2.056	2.057	2.054	2.058	2.058	2.057
444	2.055	2.055	2.054	2.056	2.058	2.055	2.059	2.059	2.058
445	2.030	2.030	2.029	2.030	2.031	2.029	2.031	2.031	2.030
446	2.032	2.033	2.031	2.032	2.033	2.032	2.036	2.036	2.034
447	2.037	2.038	2.035	2.038	2.039	2.037	2.039	2.039	2.038
448	2.039	2.040	2.039	2.040	2.041	2.040	2.041	2.041	2.040
449	2.041	2.041	2.041	2.042	2.042	2.041	2.043	2.044	2.042
450	2.043	2.044	2.043	2.046	2.046	2.044	2.049	2.048	2.046
451	2.046	2.048	2.046	2.048	2.049	2.047	2.049	2.049	2.048
452	2.048	2.048	2.047	2.049	2.049	2.047	2.049	2.049	2.049
453	2.049	2.050	2.049	2.050	2.050	2.049	2.051	2.051	2.050
454	2.050	2.051	2.050	2.051	2.052	2.051	2.053	2.053	2.051
455	2.050	2.051	2.050	2.052	2.052	2.050	2.053	2.053	2.051
456	2.051	2.051	2.050	2.051	2.052	2.051	2.053	2.053	2.052
457	2.051	2.051	2.050	2.051	2.052	2.051	2.053	2.053	2.051

TABLE F5 (continued)

458	2.518	2.519	2.511	2.520	2.520	2.514	2.522	2.522	2.518
459	2.519	2.519	2.511	2.520	2.521	2.514	2.523	2.523	2.519
460	2.518	2.518	2.511	2.520	2.520	2.513	2.522	2.522	2.518
461	2.518	2.518	2.511	2.520	2.520	2.514	2.522	2.523	2.519
462	2.518	2.519	2.512	2.521	2.521	2.514	2.523	2.523	2.519
463	2.520	2.520	2.513	2.522	2.523	2.516	2.526	2.527	2.520
464	2.520	2.521	2.514	2.523	2.524	2.516	2.528	2.528	2.521
465	2.520	2.521	2.514	2.523	2.524	2.518	2.528	2.526	2.521
466	2.520	2.522	2.517	2.523	2.526	2.519	2.528	2.528	2.521
467	2.521	2.522	2.517	2.525	2.526	2.518	2.529	2.529	2.522
468	2.520	2.521	2.517	2.524	2.524	2.519	2.528	2.528	2.521
469	2.520	2.520	2.514	2.523	2.524	2.518	2.527	2.528	2.521
470	2.518	2.519	2.512	2.521	2.521	2.515	2.524	2.524	2.519
471	2.529	2.530	2.524	2.532	2.532	2.527	2.534	2.534	2.529
472	2.529	2.530	2.523	2.531	2.532	2.526	2.534	2.533	2.529
473	2.524	2.527	2.520	2.529	2.529	2.521	2.531	2.531	2.523
474	2.524	2.525	2.520	2.528	2.528	2.520	2.530	2.530	2.523
475	2.523	2.524	2.519	2.528	2.528	2.520	2.530	2.529	2.522
476	2.523	2.524	2.519	2.527	2.527	2.520	2.529	2.529	2.521
477	2.521	2.522	2.518	2.524	2.524	2.519	2.528	2.527	2.521
478	2.521	2.522	2.517	2.523	2.524	2.519	2.528	2.528	2.520
479	2.521	2.522	2.518	2.523	2.524	2.518	2.527	2.527	2.520
480	2.517	2.517	2.511	2.519	2.519	2.511	2.520	2.520	2.516
481	2.517	2.517	2.511	2.519	2.519	2.512	2.520	2.520	2.514
482	2.518	2.518	2.511	2.518	2.519	2.513	2.521	2.521	2.514
483	2.518	2.518	2.511	2.520	2.519	2.512	2.521	2.521	2.516
484	2.422	2.422	2.418	2.423	2.424	2.419	2.426	2.427	2.422
485	2.422	2.422	2.418	2.423	2.424	2.420	2.427	2.426	2.422
486	2.422	2.422	2.418	2.423	2.424	2.420	2.427	2.426	2.422
487	2.422	2.422	2.418	2.423	2.424	2.420	2.427	2.428	2.422
488	2.421	2.421	2.417	2.423	2.424	2.420	2.426	2.427	2.421
489	2.420	2.420	2.417	2.421	2.422	2.419	2.424	2.424	2.420
490	2.420	2.420	2.416	2.422	2.423	2.419	2.424	2.425	2.420
491	2.420	2.420	2.415	2.421	2.422	2.418	2.424	2.424	2.420
492	2.420	2.420	2.414	2.421	2.422	2.418	2.424	2.424	2.420
493	2.417	2.417	2.412	2.419	2.420	2.413	2.421	2.422	2.417
494	2.417	2.417	2.413	2.419	2.420	2.414	2.421	2.422	2.418
495	2.419	2.419	2.412	2.419	2.420	2.415	2.422	2.422	2.419
496	2.418	2.418	2.412	2.419	2.420	2.413	2.421	2.422	2.418
497	1.869	1.869	1.868	1.870	1.870	1.869	1.870	1.871	1.869
498	1.869	1.869	1.868	1.870	1.870	1.869	1.870	1.871	1.869
499	1.869	1.869	1.868	1.870	1.870	1.869	1.870	1.871	1.869
500	1.869	1.869	1.867	1.869	1.870	1.869	1.870	1.870	1.869
501	1.869	1.869	1.867	1.869	1.870	1.868	1.870	1.870	1.869
502	1.869	1.869	1.867	1.870	1.870	1.868	1.870	1.870	1.869
503	1.864	1.865	1.863	1.866	1.868	1.864	1.868	1.868	1.865
504	1.865	1.868	1.863	1.867	1.868	1.865	1.869	1.869	1.867
505	1.866	1.868	1.864	1.868	1.869	1.867	1.869	1.869	1.867
506	1.866	1.867	1.864	1.868	1.869	1.866	1.869	1.869	1.866
507	1.867	1.867	1.864	1.869	1.869	1.865	1.869	1.869	1.866
508	1.867	1.867	1.864	1.868	1.868	1.864	1.869	1.869	1.867
509	1.865	1.866	1.864	1.868	1.868	1.864	1.869	1.869	1.867
510	2.429	2.430	2.427	2.431	2.432	2.428	2.433	2.434	2.430
511	2.429	2.430	2.426	2.431	2.432	2.428	2.434	2.434	2.431
512	2.429	2.430	2.427	2.432	2.432	2.429	2.434	2.437	2.430
513	2.429	2.430	2.428	2.431	2.433	2.429	2.435	2.437	2.430
514	2.430	2.431	2.428	2.432	2.433	2.429	2.435	2.437	2.431
515	2.430	2.431	2.428	2.432	2.433	2.429	2.436	2.437	2.431
516	2.430	2.431	2.428	2.432	2.433	2.429	2.435	2.437	2.431
517	2.430	2.431	2.428	2.432	2.434	2.429	2.436	2.437	2.431
518	2.430	2.431	2.428	2.432	2.434	2.429	2.436	2.437	2.431
519	2.431	2.432	2.429	2.433	2.435	2.420	2.437	2.439	2.433
520	2.431	2.432	2.429	2.434	2.436	2.421	2.438	2.438	2.433
521	2.431	2.432	2.429	2.434	2.436	2.420	2.438	2.439	2.433
522	2.431	2.433	2.429	2.434	2.438	2.421	2.438	2.439	2.432
523	2.599	2.599	2.593	2.602	2.602	2.596	2.604	2.604	2.599
524	2.599	2.599	2.594	2.602	2.602	2.596	2.604	2.605	2.599
525	2.599	2.599	2.593	2.601	2.602	2.597	2.604	2.604	2.599
526	2.597	2.599	2.592	2.600	2.600	2.593	2.602	2.602	2.597
527	2.597	2.599	2.592	2.600	2.600	2.594	2.602	2.602	2.597
528	2.597	2.599	2.590	2.600	2.600	2.591	2.601	2.601	2.597
529	2.598	2.599	2.591	2.600	2.601	2.593	2.602	2.602	2.597
530	2.598	2.599	2.592	2.600	2.601	2.594	2.602	2.603	2.598
531	2.598	2.599	2.592	2.600	2.601	2.595	2.602	2.603	2.598
532	2.598	2.599	2.592	2.600	2.601	2.594	2.602	2.602	2.598
533	2.598	2.599	2.592	2.600	2.601	2.595	2.603	2.603	2.598
534	2.598	2.599	2.593	2.600	2.601	2.594	2.602	2.602	2.598

TABLE F5 (continued)

535	2.598	2.599	2.592	2.600	2.601	2.594	2.602	2.602	2.598
536	2.150	2.152	2.151	2.153	2.153	2.152	2.155	2.155	2.152
537	2.150	2.152	2.151	2.153	2.154	2.152	2.155	2.154	2.153
538	2.150	2.151	2.150	2.153	2.154	2.151	2.155	2.156	2.153
539	2.151	2.151	2.150	2.152	2.153	2.151	2.155	2.155	2.153
540	2.150	2.151	2.150	2.152	2.152	2.151	2.155	2.155	2.152
541	2.151	2.152	2.151	2.153	2.153	2.151	2.156	2.157	2.153
542	2.151	2.152	2.152	2.154	2.154	2.152	2.158	2.158	2.154
543	2.152	2.153	2.153	2.154	2.154	2.153	2.157	2.157	2.154
544	4.870	4.903	4.919	4.892	4.919	4.926	4.910	4.934	4.929
545	4.878	4.910	4.925	4.898	4.924	4.932	4.918	4.941	4.936
546	4.881	4.915	4.930	4.902	4.929	4.937	4.922	4.946	4.940
547	4.884	4.919	4.933	4.904	4.931	4.940	4.924	4.949	4.943
548	4.880	4.915	4.930	4.901	4.929	4.937	4.921	4.947	4.941
549	1.907	1.908	1.907	1.909	1.910	1.906	1.910	1.910	1.909
550	1.909	1.909	1.907	1.910	1.910	1.909	1.911	1.911	1.910
551	1.910	1.910	1.909	1.911	1.912	1.910	1.912	1.912	1.911
552	1.912	1.913	1.910	1.913	1.914	1.912	1.915	1.916	1.913
553	1.913	1.913	1.911	1.914	1.915	1.913	1.915	1.917	1.914
554	1.912	1.913	1.913	1.914	1.916	1.913	1.917	1.917	1.915
555	1.914	1.914	1.913	1.917	1.916	1.915	1.918	1.916	1.917
556	2.268	2.268	2.267	2.269	2.270	2.267	2.271	2.271	2.269
557	2.269	2.269	2.267	2.270	2.271	2.268	2.272	2.272	2.270
558	2.269	2.270	2.268	2.271	2.272	2.269	2.273	2.273	2.270
559	2.269	2.270	2.268	2.271	2.272	2.270	2.274	2.274	2.272
560	2.270	2.271	2.269	2.272	2.273	2.270	2.274	2.274	2.271
561	2.270	2.271	2.269	2.272	2.272	2.270	2.275	2.275	2.276
562	2.270	2.271	2.269	2.272	2.273	2.270	2.274	2.276	2.272
563	2.269	2.269	2.263	2.270	2.270	2.265	2.271	2.271	2.266
564	2.269	2.269	2.263	2.271	2.270	2.267	2.272	2.272	2.269
565	2.270	2.270	2.265	2.271	2.271	2.267	2.273	2.273	2.269
566	2.270	2.270	2.265	2.272	2.272	2.268	2.273	2.273	2.270
567	2.270	2.271	2.267	2.272	2.272	2.268	2.274	2.274	2.270
568	2.687	2.689	2.684	2.695	2.691	2.688	2.694	2.695	2.690
569	2.691	2.693	2.690	2.694	2.698	2.692	2.699	2.700	2.697
570	2.693	2.698	2.693	2.698	2.699	2.696	2.701	2.703	2.699
571	2.698	2.699	2.697	2.700	2.701	2.699	2.703	2.706	2.701
572	2.700	2.701	2.699	2.703	2.706	2.701	2.708	2.709	2.702
573	2.702	2.706	2.701	2.708	2.709	2.704	2.710	2.712	2.709
574	2.703	2.708	2.702	2.709	2.710	2.705	2.711	2.713	2.709
575	2.705	2.709	2.703	2.709	2.711	2.706	2.712	2.713	2.710
576	3.145	3.148	3.142	3.149	3.152	3.147	3.154	3.157	3.150
577	3.147	3.150	3.144	3.151	3.154	3.148	3.157	3.159	3.152
578	3.148	3.150	3.144	3.152	3.154	3.148	3.158	3.159	3.153
579	3.148	3.151	3.147	3.153	3.157	3.149	3.158	3.159	3.153
580	3.149	3.152	3.148	3.153	3.157	3.150	3.159	3.160	3.154
581	3.150	3.153	3.148	3.154	3.158	3.151	3.160	3.162	3.156
582	3.150	3.154	3.149	3.156	3.159	3.152	3.161	3.162	3.157
583	3.152	3.157	3.150	3.157	3.159	3.153	3.161	3.163	3.158
584	2.931	2.935	2.932	2.934	2.940	2.937	2.940	2.943	2.940
585	2.930	2.936	2.932	2.934	2.940	2.938	2.941	2.944	2.941
586	2.929	2.932	2.930	2.932	2.938	2.933	2.939	2.942	2.939
587	2.927	2.932	2.930	2.931	2.937	2.933	2.938	2.941	2.938
588	2.925	2.930	2.928	2.929	2.934	2.931	2.934	2.939	2.935
589	4.339	4.349	4.342	4.348	4.357	4.350	4.359	4.367	4.359
590	4.338	4.349	4.342	4.348	4.358	4.350	4.359	4.365	4.359
591	4.338	4.349	4.342	4.348	4.357	4.349	4.358	4.365	4.358
592	4.338	4.349	4.342	4.346	4.356	4.349	4.359	4.365	4.356
593	4.337	4.346	4.340	4.346	4.353	4.348	4.356	4.363	4.357
594	4.338	4.349	4.342	4.348	4.358	4.350	4.359	4.367	4.359
595	6.529	6.550	6.539	6.547	6.568	6.553	6.569	6.583	6.568
596	6.529	6.549	6.538	6.545	6.567	6.552	6.568	6.583	6.568
597	6.527	6.548	6.537	6.543	6.564	6.551	6.567	6.581	6.567
598	6.527	6.549	6.537	6.544	6.564	6.550	6.566	6.582	6.567
599	3.704	3.711	3.708	3.710	3.720	3.713	3.720	3.726	3.721
600	3.705	3.713	3.709	3.711	3.720	3.716	3.720	3.728	3.721
601	3.707	3.714	3.710	3.712	3.721	3.717	3.721	3.729	3.722
602	3.708	3.717	3.711	3.713	3.722	3.718	3.722	3.730	3.724
603	3.711	3.719	3.714	3.718	3.726	3.721	3.726	3.732	3.728
604	3.712	3.720	3.716	3.719	3.728	3.722	3.728	3.733	3.729
605	3.160	3.164	3.159	3.164	3.170	3.164	3.170	3.173	3.169
606	3.161	3.166	3.160	3.166	3.170	3.163	3.177	3.174	3.169
607	3.161	3.167	3.160	3.169	3.171	3.165	3.171	3.174	3.170
608	3.162	3.168	3.161	3.168	3.171	3.166	3.173	3.177	3.170
609	3.152	3.168	3.161	3.168	3.172	3.167	3.173	3.176	3.170
610	3.163	3.169	3.161	3.168	3.173	3.167	3.173	3.176	3.170
611	4.010	4.018	4.008	4.018	4.024	4.016	4.026	4.030	4.022

TABLE F5 (continued)

612	4.012	4.020	4.009	4.020	4.028	4.018	4.029	4.032	4.024
613	4.012	4.021	4.011	4.022	4.029	4.020	4.030	4.034	4.026
614	4.014	4.022	4.012	4.022	4.029	4.020	4.030	4.037	4.027
615	4.016	4.023	4.013	4.023	4.030	4.021	4.031	4.036	4.028
616	4.018	4.025	4.015	4.026	4.032	4.023	4.032	4.039	4.030
617	4.770	4.780	4.768	4.781	4.791	4.779	4.791	4.799	4.787
618	4.771	4.782	4.769	4.782	4.792	4.780	4.793	4.800	4.789
619	4.773	4.783	4.770	4.784	4.794	4.781	4.796	4.801	4.790
620	4.775	4.785	4.772	4.787	4.796	4.783	4.798	4.803	4.792
621	4.778	4.789	4.774	4.789	4.799	4.786	4.799	4.807	4.794
622	4.780	4.790	4.778	4.790	4.801	4.789	4.801	4.809	4.798
623	7.216	7.237	7.212	7.239	7.259	7.234	7.259	7.273	7.249
624	7.228	7.250	7.224	7.251	7.271	7.249	7.270	7.285	7.261
625	7.231	7.252	7.229	7.257	7.276	7.252	7.274	7.290	7.264
626	7.236	7.259	7.232	7.260	7.279	7.257	7.279	7.294	7.269
627	7.238	7.260	7.234	7.262	7.282	7.259	7.281	7.297	7.272
628	7.243	7.267	7.241	7.269	7.289	7.264	7.288	7.302	7.278
629	3.563	3.571	3.563	3.570	3.578	3.569	3.578	3.581	3.574
630	3.564	3.572	3.563	3.571	3.579	3.570	3.579	3.582	3.575
631	3.567	3.573	3.566	3.572	3.579	3.572	3.579	3.583	3.578
632	3.568	3.574	3.567	3.572	3.579	3.572	3.580	3.584	3.576
633	3.568	3.575	3.568	3.573	3.581	3.573	3.580	3.586	3.579
634	3.568	3.574	3.568	3.574	3.580	3.574	3.581	3.585	3.579
635	3.501	3.508	3.499	3.507	3.511	3.504	3.511	3.515	3.508
636	3.504	3.510	3.501	3.510	3.514	3.507	3.514	3.518	3.510
637	3.505	3.510	3.502	3.510	3.515	3.508	3.514	3.519	3.510
638	3.506	3.510	3.501	3.510	3.516	3.508	3.514	3.519	3.511
639	3.506	3.511	3.503	3.511	3.516	3.509	3.516	3.519	3.511
640	3.508	3.512	3.503	3.512	3.518	3.509	3.518	3.520	3.513
641	3.935	3.942	3.930	3.941	3.948	3.938	3.948	3.951	3.942
642	3.938	3.944	3.932	3.943	3.950	3.940	3.949	3.953	3.944
643	3.939	3.944	3.932	3.944	3.950	3.940	3.949	3.953	3.944
644	3.939	3.944	3.933	3.944	3.951	3.940	3.950	3.956	3.946
645	3.939	3.945	3.933	3.944	3.951	3.941	3.950	3.954	3.946
646	3.939	3.946	3.934	3.946	3.952	3.942	3.951	3.957	3.947
647	4.623	4.632	4.619	4.631	4.640	4.627	4.640	4.645	4.632
648	4.624	4.632	4.619	4.634	4.640	4.628	4.640	4.645	4.632
649	4.624	4.633	4.619	4.633	4.640	4.626	4.640	4.647	4.633
650	4.624	4.633	4.619	4.633	4.641	4.626	4.641	4.646	4.633
651	4.626	4.634	4.620	4.634	4.642	4.629	4.642	4.648	4.634
652	4.627	4.634	4.620	4.634	4.642	4.629	4.642	4.649	4.634
653	5.442	5.452	5.434	5.452	5.463	5.444	5.461	5.470	5.452
654	5.443	5.453	5.434	5.454	5.465	5.444	5.463	5.471	5.453
655	5.444	5.454	5.436	5.455	5.467	5.447	5.465	5.472	5.453
656	5.443	5.454	5.436	5.456	5.467	5.446	5.465	5.472	5.454
657	5.444	5.454	5.437	5.456	5.468	5.446	5.467	5.472	5.454
658	5.444	5.454	5.437	5.457	5.468	5.446	5.467	5.472	5.454
659	8.317	8.333	8.300	8.341	8.359	8.322	8.357	8.370	8.334
660	8.319	8.337	8.301	8.343	8.360	8.324	8.359	8.373	8.336
661	8.320	8.338	8.303	8.346	8.363	8.329	8.361	8.374	8.336
662	8.321	8.339	8.303	8.347	8.363	8.327	8.360	8.375	8.338
663	8.322	8.340	8.305	8.349	8.364	8.328	8.362	8.377	8.340
664	8.328	8.346	8.310	8.353	8.370	8.333	8.368	8.381	8.345
665	1.993	1.996	1.997	1.994	1.999	1.999	1.999	2.000	1.999
666	1.994	1.998	1.998	1.997	1.999	1.999	1.999	2.000	1.999
667	1.993	1.998	1.998	1.996	1.999	1.999	1.999	2.001	1.999
668	1.998	2.000	2.000	1.999	2.002	2.001	2.001	2.003	2.002
669	1.998	2.000	2.000	1.999	2.002	2.002	2.002	2.004	2.003
670	2.351	2.358	2.356	2.354	2.359	2.358	2.359	2.362	2.360
671	2.352	2.359	2.359	2.357	2.361	2.359	2.361	2.363	2.362
672	2.354	2.360	2.359	2.359	2.363	2.360	2.363	2.365	2.363
673	2.355	2.360	2.359	2.359	2.364	2.362	2.363	2.367	2.364
674	2.358	2.362	2.359	2.360	2.364	2.363	2.365	2.368	2.366
675	3.310	3.323	3.318	3.319	3.330	3.326	3.329	3.335	3.331
676	3.312	3.326	3.320	3.321	3.332	3.329	3.332	3.338	3.333
677	3.313	3.328	3.320	3.322	3.333	3.330	3.332	3.340	3.334
678	3.317	3.329	3.323	3.327	3.337	3.332	3.335	3.342	3.338
679	1.893	1.894	1.892	1.894	1.897	1.894	1.897	1.898	1.895
680	1.893	1.894	1.893	1.894	1.896	1.894	1.898	1.898	1.897
681	1.894	1.896	1.893	1.897	1.898	1.894	1.898	1.896	1.897
682	1.896	1.896	1.894	1.898	1.898	1.897	1.898	1.899	1.897
683	1.897	1.897	1.895	1.897	1.899	1.896	1.899	1.900	1.898
684	1.897	1.897	1.895	1.898	1.899	1.897	1.899	1.900	1.898
685	2.251	2.253	2.250	2.253	2.254	2.252	2.258	2.258	2.253
686	2.252	2.253	2.250	2.254	2.257	2.253	2.258	2.259	2.255
687	2.253	2.256	2.252	2.256	2.258	2.253	2.259	2.259	2.257
688	2.253	2.257	2.251	2.257	2.259	2.254	2.259	2.260	2.257

TABLE F5 (continued)

689	2.255	2.257	2.253	2.258	2.259	2.257	2.260	2.261	2.258
690	2.257	2.259	2.253	2.258	2.259	2.258	2.261	2.262	2.259
691	2.712	2.714	2.719	2.714	2.718	2.712	2.719	2.720	2.719
692	2.713	2.717	2.710	2.716	2.719	2.713	2.721	2.722	2.718
693	2.716	2.719	2.713	2.720	2.722	2.716	2.723	2.724	2.720
694	2.716	2.719	2.712	2.720	2.721	2.717	2.723	2.723	2.720
695	2.715	2.719	2.712	2.719	2.720	2.718	2.723	2.723	2.719
696	2.716	2.719	2.712	2.719	2.721	2.716	2.722	2.723	2.719
697	3.216	3.219	3.211	3.220	3.223	3.216	3.227	3.228	3.221
698	3.218	3.221	3.213	3.222	3.226	3.220	3.229	3.230	3.224
699	3.220	3.223	3.217	3.225	3.229	3.222	3.230	3.232	3.227
700	3.221	3.225	3.218	3.226	3.230	3.223	3.232	3.234	3.227
701	3.222	3.227	3.219	3.228	3.231	3.224	3.234	3.235	3.229
702	3.223	3.227	3.220	3.227	3.231	3.224	3.233	3.235	3.229
703	1.872	1.873	1.870	1.873	1.874	1.872	1.877	1.876	1.874
704	1.877	1.878	1.874	1.879	1.879	1.877	1.879	1.880	1.878
705	1.878	1.879	1.875	1.879	1.880	1.878	1.880	1.880	1.879
706	1.878	1.879	1.877	1.879	1.880	1.879	1.880	1.881	1.879
707	1.879	1.880	1.878	1.880	1.881	1.879	1.881	1.882	1.880
708	1.880	1.881	1.879	1.881	1.882	1.880	1.882	1.882	1.881
709	2.221	2.222	2.219	2.222	2.224	2.221	2.224	2.227	2.223
710	2.222	2.223	2.220	2.223	2.226	2.222	2.227	2.226	2.224
711	2.223	2.224	2.221	2.226	2.226	2.223	2.228	2.229	2.224
712	2.223	2.225	2.221	2.224	2.227	2.223	2.229	2.229	2.227
713	2.224	2.226	2.221	2.226	2.228	2.223	2.229	2.229	2.226
714	2.224	2.226	2.221	2.227	2.229	2.224	2.229	2.230	2.226
715	2.740	2.742	2.735	2.742	2.746	2.740	2.747	2.749	2.742
716	2.740	2.742	2.737	2.743	2.748	2.740	2.748	2.749	2.743
717	2.741	2.743	2.738	2.745	2.748	2.741	2.749	2.750	2.743
718	2.743	2.744	2.738	2.745	2.748	2.742	2.749	2.751	2.744
719	2.743	2.744	2.739	2.746	2.749	2.742	2.749	2.751	2.746
720	2.743	2.747	2.740	2.746	2.749	2.742	2.750	2.752	2.747
721	1.880	1.880	1.879	1.881	1.882	1.880	1.882	1.882	1.880
722	1.881	1.882	1.880	1.882	1.883	1.881	1.883	1.883	1.881
723	1.882	1.883	1.881	1.883	1.884	1.882	1.884	1.886	1.883
724	1.883	1.884	1.882	1.883	1.886	1.883	1.886	1.887	1.883
725	1.884	1.884	1.882	1.885	1.887	1.884	1.887	1.889	1.885
726	1.887	1.888	1.883	1.888	1.889	1.886	1.888	1.889	1.887
727	2.220	2.221	2.218	2.221	2.223	2.219	2.223	2.224	2.221
728	2.221	2.222	2.219	2.222	2.224	2.220	2.224	2.226	2.222
729	2.222	2.223	2.220	2.224	2.226	2.222	2.227	2.227	2.223
730	2.223	2.224	2.221	2.224	2.228	2.223	2.227	2.228	2.224
731	2.223	2.224	2.221	2.226	2.228	2.223	2.228	2.229	2.224
732	2.224	2.226	2.221	2.226	2.228	2.224	2.228	2.230	2.226
733	2.723	2.727	2.721	2.728	2.729	2.723	2.729	2.730	2.725
734	2.723	2.727	2.721	2.728	2.730	2.723	2.729	2.731	2.727
735	2.725	2.729	2.722	2.729	2.730	2.725	2.730	2.732	2.729
736	2.727	2.729	2.723	2.729	2.731	2.726	2.732	2.734	2.729
737	2.728	2.730	2.724	2.730	2.732	2.726	2.732	2.737	2.730
738	2.730	2.731	2.727	2.731	2.733	2.729	2.734	2.738	2.730

TABLE F6

THE MEAN AND STD DEVIATION OF MILLIVOLT POSNS 10 TO18

K	XBAR	STD	TEMP	K	XBAR	STD	TEMP	K	XBAR	STD	TEMP
1	2.04889	0.00117	51.031	2	2.05156	0.00151	51.095	3	2.05422	0.00130	51.159
4	2.05622	0.00097	51.207	5	2.05689	0.00136	51.222	6	2.05744	0.00113	51.236
7	2.05778	0.00156	51.244	8	2.06400	0.00194	51.393	9	2.05944	0.00151	51.284
10	2.05911	0.00127	51.276	11	2.06044	0.00159	51.308	12	2.06156	0.00174	51.334
13	2.06111	0.00136	51.323	14	2.06156	0.00101	51.334	15	2.05833	0.00100	51.257
16	2.05867	0.00100	51.265	17	2.05889	0.00136	51.270	18	2.05956	0.00133	51.286
19	2.05967	0.00122	51.289	20	2.05856	0.00113	51.262	21	2.05911	0.00105	51.276
22	2.06011	0.00117	51.300	23	2.06089	0.00127	51.318	24	2.06200	0.00150	51.345
25	2.06256	0.00167	51.355	26	2.06156	0.00159	51.334	27	2.06167	0.00132	51.337
28	2.06122	0.00156	51.326	29	1.47922	0.00067	37.204	30	1.47656	0.00053	37.138
31	1.47267	0.00112	37.042	32	1.46600	0.00050	36.870	33	1.46333	0.00071	36.812
34	1.45100	0.00000	36.508	35	1.45200	0.00000	36.533	36	1.45233	0.00050	36.541
37	1.45233	0.00050	36.541	38	1.45456	0.00068	36.596	39	1.45600	0.00000	36.632
40	1.45644	0.00053	36.643	41	1.45733	0.00050	36.664	42	1.45600	0.00000	36.631
43	2.49656	0.00151	61.628	44	2.49589	0.00190	61.612	45	2.49589	0.00190	61.612
46	2.49633	0.00194	61.623	47	2.49600	0.00206	61.615	48	2.49556	0.00194	61.604
49	2.49500	0.00206	61.591	50	2.50111	0.00162	61.734	51	2.50000	0.00173	61.708
52	2.49989	0.00190	61.706	53	2.49878	0.00148	61.680	54	2.49711	0.00176	61.641
55	2.49667	0.00173	61.630	56	2.10444	0.00113	52.359	57	2.09933	0.00122	52.237
58	2.09511	0.00162	52.136	59	2.09256	0.00194	52.075	60	2.08989	0.00136	52.011
61	2.11422	0.00120	52.592	62	2.10911	0.00117	52.470	63	2.10622	0.00140	52.401
64	2.10467	0.00150	52.364	65	2.10333	0.00158	52.332	66	2.09900	0.00122	52.229
67	2.09556	0.00113	52.218	68	2.09811	0.00127	52.207	69	2.09122	0.00109	52.043
70	2.08967	0.00087	52.006	71	2.08689	0.00078	51.987	72	2.08711	0.00130	51.945
73	2.08656	0.00167	51.932	74	2.08322	0.00109	51.852	75	2.07911	0.00076	51.754
76	2.07967	0.00132	51.767	77	2.07944	0.00068	51.762	78	2.07278	0.00120	51.602
79	2.07578	0.00172	51.674	80	2.07722	0.00120	51.709	81	2.08956	0.00113	52.003
82	2.07700	0.00173	51.703	83	2.08300	0.00200	51.847	84	2.07967	0.00100	51.767
85	2.07444	0.00213	51.642	86	2.07356	0.00213	51.621	87	2.07344	0.00194	51.618
88	2.09889	0.00117	52.226	89	2.08811	0.00162	51.969	90	2.08100	0.00122	51.799
91	2.07989	0.00078	51.772	92	2.07978	0.00097	51.770	93	2.08411	0.00209	51.873
94	1.45900	0.00000	36.706	95	1.46433	0.00112	36.837	96	1.46367	0.00087	36.821
97	1.46969	0.00060	36.974	98	1.46989	0.00033	36.974	99	1.46856	0.00053	36.941
100	1.46833	0.00050	36.936	101	1.45978	0.00044	36.725	102	1.46700	0.00000	36.903
103	1.46756	0.00073	36.916	104	1.46767	0.00071	36.919	105	1.46622	0.00109	36.884
106	1.46333	0.00141	36.812	107	2.54478	0.00273	62.756	108	2.53711	0.00267	62.577
109	2.52944	0.00201	62.397	110	2.54922	0.00130	62.860	111	2.53633	0.00304	62.558
112	2.52967	0.00187	62.403	113	2.52533	0.00300	62.301	114	2.51989	0.00190	62.174
115	2.51656	0.00309	62.096	116	2.51156	0.00167	61.979	117	2.50989	0.00176	61.940
118	2.50211	0.00247	61.758	119	2.50089	0.00163	61.729	120	2.11800	0.00180	52.682
121	2.11233	0.00160	52.547	122	2.10767	0.00150	52.436	123	2.10178	0.00179	52.295
124	2.09700	0.00206	52.181	125	2.09233	0.00200	52.070	126	2.09056	0.00101	52.027
127	2.09133	0.00166	52.046	128	2.11567	0.00255	52.626	129	2.10978	0.00097	52.486
130	2.10778	0.00164	52.438	131	2.10211	0.00136	52.303	132	2.09633	0.00235	52.165
133	2.11000	0.00087	52.491	134	2.10600	0.00229	52.396	135	2.10278	0.00217	52.319
136	2.11022	0.00083	52.496	137	2.10411	0.00271	52.351	138	2.08744	0.00186	51.953
139	2.11167	0.00150	52.531	140	2.10556	0.00213	52.385	141	2.09956	0.00080	52.242
142	2.09444	0.00224	52.120	143	2.08911	0.00105	51.993	144	2.08511	0.00276	51.897
145	2.08433	0.00224	51.878	146	2.08689	0.00093	51.987	147	2.08700	0.00194	51.942
148	2.08078	0.00120	51.794	149	2.08056	0.00101	51.788	150	2.07956	0.00124	51.764
151	2.07844	0.00133	51.738	152	2.07778	0.00172	51.722	153	2.07678	0.00180	51.698
154	2.07322	0.00228	51.613	155	2.07378	0.00249	51.626	156	2.07256	0.00180	51.597
157	2.08967	0.00100	52.006	158	2.08444	0.00213	51.881	159	2.10289	0.00169	52.321
160	2.09867	0.00132	52.221	161	2.09311	0.00215	52.088	162	2.08978	0.00097	52.009
163	2.08722	0.00172	51.947	164	2.08367	0.00255	51.863	165	2.08100	0.00122	51.799
166	2.07533	0.00250	51.603	167	2.07333	0.00157	51.616	168	2.06944	0.00124	51.523
169	2.06956	0.00101	51.525	170	2.07233	0.00173	51.592	171	2.07256	0.00167	51.597
172	1.45000	0.00000	36.484	173	1.44900	0.00000	36.459	174	1.44478	0.00083	36.355
175	1.44333	0.00050	36.319	176	1.44133	0.00050	36.270	177	1.44022	0.00044	36.242
178	1.44000	0.00000	36.237	179	1.44022	0.00044	36.242	180	1.44056	0.00053	36.251
181	1.44133	0.00050	36.270	182	1.44100	0.00071	36.262	183	1.44122	0.00067	36.267
184	1.44133	0.00050	36.270	185	2.49656	0.00246	61.628	186	2.50167	0.00265	61.747
187	2.50067	0.00194	61.724	188	2.52311	0.00296	62.249	189	2.50756	0.00251	61.885
190	2.55233	0.00275	62.932	191	2.53911	0.00209	62.623	192	2.53078	0.00220	62.429
193	2.51233	0.00260	61.997	194	2.50911	0.00196	61.922	195	2.50422	0.00295	61.807
196	2.50178	0.00249	61.750	197	2.50333	0.00316	61.786	198	2.09856	0.00086	52.218
199	2.09389	0.00220	52.107	200	2.09044	0.00113	52.024	201	2.08867	0.00112	51.982
202	2.05667	0.00212	51.934	203	2.08344	0.00240	51.857	204	2.08289	0.00215	51.844
205	2.08133	0.00150	51.807	206	2.08067	0.00100	51.791	207	2.07889	0.00093	51.748
208	2.07900	0.00100	51.751	209	2.07644	0.00159	51.736	210	2.07278	0.00172	51.602
211	2.07811	0.00183	51.730	212	2.07900	0.00100	51.751	213	2.07844	0.00159	51.738

TABLE F6 (continued)

214	2.07844	0.00159	51.736	215	2.07856	0.00124	51.740	216	2.09889	0.00033	52.226
217	2.09556	0.00235	52.146	218	2.09156	0.00167	52.051	219	2.08922	0.00120	51.995
220	2.08644	0.00213	51.929	221	2.08489	0.00226	51.892	222	2.08200	0.00150	51.823
223	2.07856	0.00133	51.740	224	2.07144	0.00113	51.570	225	2.07144	0.00133	51.570
226	2.07000	0.00122	51.536	227	2.07178	0.00139	51.578	228	2.07256	0.00174	51.597
229	2.06722	0.00172	51.470	230	2.06844	0.00167	51.499	231	2.06867	0.00100	51.504
232	2.07207	0.00166	51.600	233	2.07389	0.00203	51.629	234	2.07500	0.00224	51.655
235	2.07389	0.00203	51.629	236	2.07544	0.00235	51.666	237	2.07267	0.00166	51.600
238	2.06933	0.00132	51.520	239	2.06744	0.00167	51.475	240	2.06589	0.00237	51.438
241	2.07156	0.00159	51.573	242	2.07189	0.00145	51.581	243	2.07178	0.00120	51.578
244	2.07144	0.00101	51.570	245	2.07189	0.00154	51.581	246	2.07200	0.00141	51.584
247	2.07233	0.00158	51.592	248	2.07344	0.00194	51.618	249	2.07289	0.00145	51.605
250	1.44356	0.00053	36.325	251	1.44278	0.00063	36.305	252	1.44244	0.00053	36.297
253	1.44200	0.00000	36.286	254	1.44122	0.00067	36.267	255	1.44000	0.00000	36.237
256	1.43989	0.00033	36.234	257	1.44000	0.00000	36.237	258	1.43967	0.00050	36.229
259	1.43822	0.00044	36.193	260	1.43889	0.00033	36.210	261	1.43889	0.00033	36.210
262	1.43900	0.00000	36.212	263	2.50678	0.00277	61.867	264	2.50822	0.00244	61.901
265	2.51178	0.00228	61.984	266	2.51278	0.00262	62.008	267	2.51322	0.00277	62.018
268	2.51400	0.00274	62.036	269	2.51367	0.00292	62.028	270	2.51611	0.00252	62.086
271	2.51678	0.00291	62.101	272	2.51667	0.00292	62.099	273	2.51689	0.00293	62.104
274	2.51456	0.00305	62.049	275	2.51500	0.00304	62.060	276	2.11689	0.00183	52.655
277	2.11222	0.00139	52.544	278	2.11211	0.00154	52.542	279	2.11022	0.00109	52.496
280	2.10922	0.00130	52.473	281	2.10789	0.00209	52.441	282	2.10500	0.00187	52.372
283	2.10022	0.00044	52.258	284	2.10022	0.00044	52.258	285	2.10033	0.00050	52.261
286	2.10144	0.00142	52.287	287	2.10278	0.00217	52.319	288	2.10289	0.00215	52.321
289	2.10044	0.00073	52.263	290	2.10122	0.00130	52.282	291	2.10089	0.00165	52.274
292	2.10044	0.00088	52.263	293	2.12433	0.00212	52.833	294	2.12022	0.00109	52.735
295	2.11678	0.00192	52.653	296	2.11200	0.00132	52.539	297	2.10933	0.00112	52.475
298	2.10022	0.00044	52.256	299	2.09822	0.00109	52.210	300	2.09733	0.00187	52.189
301	2.09678	0.00205	52.176	302	2.08944	0.00133	52.001	303	2.08956	0.00113	52.003
304	2.08578	0.00166	51.913	305	2.08611	0.00242	51.921	306	2.08567	0.00224	51.910
307	2.07856	0.00133	51.740	308	2.07567	0.00100	51.743	309	2.07900	0.00100	51.751
310	2.07967	0.00100	51.767	311	2.08078	0.00148	51.794	312	2.08069	0.00130	51.796
313	2.08056	0.00101	51.788	314	2.08033	0.00112	51.783	315	2.04322	0.00164	50.895
316	2.04467	0.00180	50.930	317	2.04656	0.00159	50.975	318	2.04756	0.00113	50.999
319	2.04833	0.00122	51.018	320	2.04867	0.00100	51.025	321	2.04889	0.00078	51.031
322	2.05056	0.00133	51.071	323	2.05044	0.00113	51.068	324	2.05097	0.00132	51.074
325	2.05089	0.00145	51.079	326	2.05456	0.00167	51.167	327	2.05733	0.00158	51.233
328	1.44533	0.00071	36.369	329	1.44600	0.00000	36.385	330	1.44478	0.00097	36.355
331	1.44456	0.00053	36.349	332	1.44456	0.00053	36.349	333	1.44444	0.00053	36.347
334	1.44433	0.00050	36.344	335	1.44300	0.00000	36.311	336	1.44333	0.00050	36.319
337	1.44367	0.00100	36.327	338	1.44289	0.00033	36.306	339	1.44344	0.00055	36.322
340	1.44411	0.00033	36.338	341	2.50322	0.00211	61.784	342	2.49467	0.00229	61.584
343	2.45967	0.00132	61.406	344	2.48078	0.00172	61.256	345	2.47678	0.00130	61.211
346	2.47600	0.00255	61.140	347	2.47433	0.00278	61.107	348	2.46922	0.00139	60.987
349	2.46944	0.00151	60.992	350	2.46956	0.00133	60.995	351	2.46944	0.00151	60.992
352	2.47022	0.00156	61.011	353	2.47133	0.00180	61.037	354	2.07878	0.00097	51.746
355	2.07522	0.00192	51.661	356	2.07267	0.00132	51.600	357	2.07033	0.00050	51.544
358	2.06956	0.00053	51.525	359	2.06744	0.00133	51.475	360	2.06733	0.00122	51.472
361	2.06189	0.00127	51.342	362	2.06356	0.00194	51.382	363	2.06256	0.00167	51.358
364	2.05978	0.00083	51.292	365	2.06033	0.00067	51.305	366	2.06067	0.00109	51.313
367	2.04000	0.00087	50.818	368	2.04156	0.00133	50.856	369	2.04267	0.00141	50.867
370	2.04444	0.00207	50.925	371	2.04567	0.00240	50.954	372	2.04844	0.00073	51.020
373	2.04556	0.00088	51.023	374	2.04833	0.00057	51.016	375	2.04756	0.00133	50.999
376	2.04544	0.00174	50.949	377	2.04711	0.00154	50.989	378	2.04667	0.00144	50.978
379	2.04769	0.00105	51.007	380	2.07089	0.00078	51.557	381	2.06689	0.00076	51.509
382	2.06489	0.00183	51.414	383	2.06167	0.00100	51.337	384	2.06000	0.00087	51.297
385	2.05644	0.00224	51.212	386	2.05489	0.00220	51.175	387	2.05411	0.00190	51.156
388	2.05222	0.00130	51.111	389	2.05111	0.00117	51.084	390	2.04678	0.00217	50.981
391	2.04711	0.00169	50.989	392	2.04689	0.00176	50.983	393	2.05178	0.00119	51.100
394	2.05389	0.00190	51.151	395	2.05533	0.00167	51.209	396	2.05656	0.00113	51.262
397	2.05667	0.00100	51.265	398	2.06078	0.00120	51.315	399	2.06167	0.00067	51.337
400	2.06244	0.00167	51.355	401	2.06422	0.00179	51.396	402	2.06544	0.00187	51.427
403	2.06767	0.00100	51.480	404	2.06767	0.00122	51.480	405	2.06556	0.00219	51.430
406	2.47422	0.00239	61.104	407	2.47767	0.00229	61.185	408	2.47922	0.00139	61.222
409	2.48011	0.00145	61.243	410	2.48133	0.00160	61.271	411	2.48211	0.00237	61.289
412	2.48233	0.00240	61.295	413	2.48211	0.00247	61.289	414	2.48433	0.00310	61.341
415	2.48556	0.00288	61.370	416	2.48678	0.00268	61.399	417	2.48800	0.00212	61.427
418	2.48922	0.00139	61.456	419	1.45722	0.00044	36.662	420	1.45367	0.00087	36.574
421	1.45200	0.00000	36.533	422	1.45111	0.00033	36.511	423	1.45000	0.00000	36.484
424	1.44756	0.00053	36.423	425	1.44822	0.00067	36.440	426	1.44756	0.00053	36.423
427	1.44456	0.00053	36.349	428	1.44144	0.00053	36.273	429	1.44200	0.00000	36.286
430	1.44200	0.00000	36.286	431	1.44156	0.00053	36.275	432	2.06122	0.00097	51.320
433	2.06111	0.00078	51.323	434	2.06144	0.00101	51.331	435	2.06089	0.00078	51.315
436	2.06067	0.00087	51.313	437	2.05978	0.00063	51.292	438	2.05333	0.00160	51.137
439	2.05422	0.00233	51.159	440	2.05433	0.00229	51.161	441	2.05400	0.00212	51.153
442	2.05522	0.00199	51.183	443	2.05578	0.00166	51.196	444	2.05656	0.00194	51.214

TABLE F6 (continued)

445	2.03011	0.00078	50.582	446	2.03322	0.00179	50.656	447	2.03778	0.00130	50.765
448	2.04011	0.00078	50.821	449	2.04189	0.00105	50.864	450	2.04544	0.00213	50.949
451	2.04778	0.00120	51.004	452	2.04633	0.00067	51.016	453	2.04989	0.00076	51.055
454	2.05133	0.00112	51.090	455	2.05133	0.00122	51.090	456	2.05156	0.00101	51.095
457	2.05144	0.00101	51.092	458	2.51822	0.00363	62.135	459	2.51878	0.00396	62.148
460	2.51800	0.00377	62.130	461	2.51833	0.00377	62.136	462	2.51889	0.00379	62.151
463	2.52100	0.00421	62.200	464	2.52189	0.00451	62.221	465	2.52189	0.00451	62.221
466	2.52267	0.00394	62.239	467	2.52322	0.00435	62.252	468	2.52244	0.00364	62.234
469	2.52167	0.00439	62.216	470	2.51922	0.00293	62.158	471	2.53011	0.00336	62.413
472	2.52967	0.00346	62.403	473	2.52611	0.00423	62.319	474	2.52533	0.00391	62.301
475	2.52478	0.00409	62.288	476	2.52433	0.00384	62.276	477	2.52267	0.00339	62.239
478	2.52244	0.00378	62.234	479	2.52222	0.00338	62.226	480	2.51689	0.00352	62.104
481	2.51056	0.00343	62.096	482	2.51700	0.00354	62.106	483	2.51733	0.00367	62.114
484	2.42256	0.00292	59.892	485	2.42289	0.00314	59.900	486	2.42289	0.00314	59.900
487	2.42289	0.00314	59.900	488	2.42222	0.00311	59.884	489	2.42078	0.00226	59.850
490	2.42100	0.00278	59.855	491	2.42044	0.00283	59.842	492	2.42033	0.00306	59.840
493	2.41756	0.00340	59.774	494	2.41789	0.00302	59.782	495	2.41856	0.00321	59.798
496	2.41789	0.00337	59.782	497	1.86944	0.00088	46.716	498	1.86944	0.00086	46.718
499	1.86944	0.00088	46.718	500	1.86911	0.00093	46.710	501	1.86900	0.00100	46.707
502	1.86911	0.00105	46.710	503	1.86567	0.00194	46.627	504	1.86678	0.00205	46.654
505	1.86744	0.00167	46.670	506	1.85733	0.00173	46.667	507	1.86711	0.00185	46.662
508	1.86700	0.00187	46.659	509	1.86667	0.00200	46.651	510	2.43044	0.00236	60.077
511	2.43056	0.00265	60.030	512	2.43111	0.00302	60.093	513	2.43133	0.00304	60.096
514	2.43178	0.00286	60.108	515	2.43189	0.00302	60.111	516	2.43178	0.00256	60.106
517	2.43200	0.00308	60.114	518	2.43200	0.00308	60.114	519	2.43211	0.00546	60.116
520	2.43244	0.00527	60.124	521	2.43244	0.00506	60.124	522	2.43278	0.00561	60.132
523	2.59978	0.00367	64.039	524	2.60000	0.00361	64.044	525	2.59978	0.00349	64.039
526	2.59800	0.00361	63.998	527	2.59811	0.00344	64.000	528	2.59733	0.00415	63.952
529	2.59811	0.00389	64.000	530	2.59856	0.00361	64.011	531	2.59867	0.00346	64.013
532	2.59844	0.00347	64.008	533	2.59878	0.00360	64.016	534	2.59856	0.00324	64.011
535	2.59844	0.00347	64.008	536	2.15256	0.00167	53.505	537	2.15267	0.00156	53.508
538	2.15255	0.00219	53.505	539	2.15233	0.00160	53.500	540	2.15200	0.00187	53.492
541	2.15300	0.00218	53.516	542	2.15389	0.00257	53.537	543	2.15411	0.00176	53.542
544	4.91133	0.02035	115.289	545	4.91500	0.01999	115.430	546	4.92244	0.02051	115.524
547	4.92522	0.02057	115.582	548	4.92233	0.02115	115.521	549	1.90867	0.00122	47.664
550	1.90956	0.00124	47.686	551	1.91078	0.00109	47.715	552	1.91311	0.00176	47.771
553	1.91389	0.00169	47.790	554	1.91444	0.00168	47.803	555	1.91578	0.00186	47.835
556	2.26889	0.00154	56.267	557	2.26978	0.00172	56.286	558	2.27056	0.00181	56.307
559	2.27111	0.00209	56.320	560	2.27156	0.00161	56.330	561	2.27222	0.00254	56.346
562	2.27189	0.00220	56.338	563	2.26844	0.00274	56.257	564	2.26911	0.00286	56.272
565	2.26939	0.00262	56.291	566	2.27033	0.00260	56.301	567	2.27069	0.00242	56.315
568	2.66978	0.00338	66.132	569	2.69489	0.00369	66.251	570	2.69776	[illegible]	66.318
571	2.70044	0.00274	66.380	572	2.70322	0.00360	66.444	573	2.70678	0.00377	66.527
574	2.70778	0.00370	66.550	575	2.70689	0.00322	66.576	576	3.14933	0.00456	76.568
577	3.15133	0.00480	76.733	578	3.15178	0.00487	76.743	579	3.15278	0.00444	76.766
580	3.15356	0.00433	76.784	581	3.15467	0.00472	76.809	582	3.15556	0.00467	76.829
583	3.15667	0.00427	76.854	584	2.93689	0.00414	71.835	585	2.93733	0.00466	71.846
586	2.93489	0.00465	71.789	587	2.93411	0.00459	71.772	588	2.93167	0.00424	71.716
589	4.35222	0.00898	103.339	590	4.35200	0.00886	103.334	591	4.35156	0.00862	103.325
592	4.35133	0.00677	103.320	593	4.34956	0.00841	103.281	594	4.35222	0.00924	103.339
595	6.55622	0.01706	149.032	596	6.55544	0.01723	149.016	597	6.55389	0.01714	148.985
598	6.55400	0.01716	148.967	599	3.71478	0.00726	89.384	600	3.71589	0.00711	89.409
601	3.71700	0.00693	89.433	602	3.71833	0.00695	89.465	603	3.72167	0.00667	89.537
604	3.72300	0.00691	89.566	605	3.16589	0.00403	77.064	606	3.16733	0.00574	77.097
607	3.16756	0.00475	77.102	608	3.16844	0.00508	77.122	609	3.16744	0.00716	77.099
610	3.16911	0.00523	77.137	611	4.01911	0.00722	96.092	612	4.02133	0.00773	96.141
613	4.02278	0.00765	96.172	614	4.02367	0.00795	96.192	615	4.02456	0.00740	96.211
616	4.02667	0.00748	96.258	617	4.78289	0.01014	112.567	618	4.78422	0.01027	112.595
619	4.78578	0.01041	112.628	620	4.78789	0.01040	112.673	621	4.79056	0.01050	112.729
622	4.79289	0.01023	112.779	623	7.24200	0.02019	162.530	624	7.25433	0.01994	162.778
625	7.25833	0.02025	162.856	626	7.26278	0.02019	162.943	627	7.26500	0.02055	162.986
628	7.27122	0.02054	163.107	629	3.57189	0.00645	86.205	630	3.57278	0.00663	86.225
631	3.57433	0.00579	86.259	632	3.57489	0.00573	86.272	633	3.57589	0.00609	86.294
634	3.57589	0.00582	86.294	635	3.50711	0.00509	84.757	636	3.50978	0.00526	84.817
637	3.51033	0.00517	84.829	638	3.51056	0.00559	84.834	639	3.51133	0.00507	84.851
640	3.51256	0.00546	84.879	641	3.94167	0.00673	94.393	642	3.94367	0.00650	94.437
643	3.94389	0.00639	94.442	644	3.94478	0.00696	94.461	645	3.94478	0.00651	94.461
646	3.94600	0.00700	94.488	647	4.63211	0.00846	109.354	648	4.63267	0.00826	109.366
649	4.63300	0.00863	109.373	650	4.63311	0.00805	109.375	651	4.63433	0.00872	109.401
652	4.63456	0.00880	109.406	653	5.45222	0.01126	126.608	654	5.45333	0.01176	126.631
655	5.45478	0.01164	126.661	656	5.45500	0.01167	126.665	657	5.45556	0.01171	126.677
658	5.45567	0.01172	126.679	659	8.33700	0.02236	183.495	660	8.33911	0.02262	183.535
661	8.34100	0.02271	183.570	662	8.34144	0.02261	183.579	663	8.34300	0.02270	183.608
664	8.34822	0.02258	183.706	665	1.99733	0.00250	49.796	666	1.99811	0.00176	49.815
667	1.99600	0.00229	49.812	668	2.00067	0.00158	49.876	669	2.00111	0.00190	49.887
670	2.35744	0.00332	58.359	671	2.35922	0.00327	58.401	672	2.36067	0.00326	58.435
673	2.36144	0.00357	58.453	674	2.36278	0.00355	58.465	675	3.32456	0.00783	80.655

676	3.32700	0.00808	80.710	677	3.32800	0.00829	80.733	678	3.33111	0.00793	80.803
679	1.89489	0.00203	47.332	680	1.89522	0.00205	47.340	681	1.89611	0.00196	47.362
682	1.89700	0.00150	47.383	683	1.89756	0.00159	47.396	684	1.89778	0.00146	47.402
685	2.25356	0.00279	55.904	686	2.25456	0.00296	55.928	687	2.25589	0.00267	55.959
688	2.25633	0.00304	55.970	689	2.25756	0.00246	55.999	690	2.25844	0.00255	56.020
691	2.71633	0.00328	66.746	692	2.71650	0.00397	66.754	693	2.71944	0.00347	66.821
694	2.71900	0.00354	66.810	695	2.71867	0.00350	66.803	696	2.71856	0.00343	66.800
697	3.22033	0.00529	78.299	698	3.22256	0.00539	78.349	699	3.22500	0.00495	78.405
700	3.22622	0.00519	78.432	701	3.22767	0.00534	78.465	702	3.22707	0.00487	78.465
703	1.87367	0.00250	46.820	704	1.87789	0.00176	46.922	705	1.87867	0.00156	46.941
706	1.87911	0.00117	46.952	707	1.88000	0.00122	46.973	708	1.88069	0.00105	46.994
709	2.22256	0.00230	55.169	710	2.22389	0.00262	55.201	711	2.22489	0.00257	55.224
712	2.22533	0.00283	55.235	713	2.22575	0.00273	55.246	714	2.22622	0.00291	55.256
715	2.74256	0.00425	67.356	716	2.74333	0.00418	67.374	717	2.74422	0.00409	67.395
718	2.74489	0.00395	67.410	719	2.74544	0.00364	67.423	720	2.74644	0.00397	67.446
721	1.88067	0.00112	46.989	722	1.88178	0.00109	47.010	723	1.88311	0.00145	47.048
724	1.88411	0.00176	47.072	725	1.88522	0.00211	47.099	726	1.88722	0.00166	47.147
727	2.22111	0.00196	55.135	728	2.22222	0.00217	55.161	729	2.22378	0.00244	55.193
730	2.22467	0.00245	55.219	731	2.22511	0.00276	55.230	732	2.22589	0.00267	55.248
733	2.72611	0.00322	66.975	734	2.72656	0.00347	66.985	735	2.72789	0.00316	67.016
736	2.72889	0.00330	67.039	737	2.73011	0.00355	67.060	738	2.73144	0.00321	67.099

TABLE F7

Raw Experimental Data

Thermocouple Wires Numbers 19 to 27

MILLIVOLTS READ IN FOR PUSITIONS 19 TO 27 ARE

1	2.051	2.050	2.048	2.049	2.049	2.049	2.048
2	2.054	2.054	2.050	2.053	2.053	2.053	2.052
3	2.056	2.056	2.053	2.055	2.055	2.055	2.053
4	2.058	2.057	2.055	2.057	2.057	2.057	2.056
5	2.059	2.058	2.056	2.059	2.059	2.059	2.058
6	2.060	2.059	2.057	2.059	2.059	2.059	2.058
7	2.060	2.060	2.057	2.059	2.059	2.059	2.058
8	2.067	2.067	2.064	2.067	2.067	2.067	2.065
9	2.062	2.062	2.059	2.061	2.061	2.061	2.061
10	2.062	2.062	2.059	2.061	2.061	2.061	2.060
11	2.063	2.063	2.059	2.062	2.062	2.062	2.060
12	2.063	2.063	2.060	2.063	2.063	2.063	2.061
13	2.064	2.063	2.060	2.063	2.063	2.063	2.061
14	2.064	2.064	2.061	2.064	2.064	2.064	2.062
15	2.059	2.060	2.057	2.058	2.058	2.056	2.058
16	2.061	2.060	2.058	2.060	2.060	2.060	2.059
17	2.061	2.061	2.058	2.061	2.061	2.060	2.059
18	2.062	2.061	2.059	2.061	2.061	2.060	2.060
19	2.061	2.061	2.059	2.061	2.061	2.061	2.060
20	2.060	2.060	2.058	2.060	2.060	2.060	2.059
21	2.061	2.061	2.058	2.060	2.060	2.060	2.059
22	2.062	2.061	2.059	2.060	2.060	2.060	2.059
23	2.063	2.063	2.060	2.063	2.063	2.063	2.061
24	2.064	2.063	2.062	2.064	2.064	2.064	2.063
25	2.064	2.064	2.062	2.063	2.063	2.063	2.063
26	2.064	2.064	2.061	2.063	2.063	2.063	2.061
27	2.063	2.063	2.060	2.063	2.063	2.063	2.061
28	2.063	2.063	2.060	2.062	2.062	2.062	2.061
29	1.480	1.480	1.478	1.479	1.479	1.479	1.479
30	1.477	1.477	1.477	1.477	1.477	1.477	1.477
31	1.474	1.474	1.474	1.474	1.474	1.474	1.474
32	1.468	1.467	1.466	1.467	1.467	1.467	1.467
33	1.464	1.464	1.463	1.464	1.464	1.464	1.464
34	1.451	1.451	1.451	1.451	1.451	1.451	1.451
35	1.452	1.452	1.452	1.452	1.452	1.452	1.452
36	1.453	1.453	1.452	1.453	1.453	1.453	1.453
37	1.453	1.453	1.452	1.453	1.453	1.453	1.453
38	1.456	1.456	1.454	1.455	1.455	1.455	1.455
39	1.456	1.456	1.455	1.456	1.456	1.456	1.456
40	1.457	1.457	1.456	1.457	1.457	1.456	1.457
41	1.458	1.458	1.456	1.457	1.458	1.456	1.458
42	1.458	1.458	1.457	1.458	1.458	1.456	1.458
43	2.497	2.497	2.494	2.497	2.497	2.497	2.495
44	2.498	2.496	2.494	2.497	2.497	2.497	2.493
45	2.498	2.497	2.494	2.497	2.497	2.497	2.494
46	2.499	2.498	2.494	2.497	2.497	2.497	2.494
47	2.498	2.498	2.493	2.497	2.497	2.497	2.494
48	2.498	2.497	2.493	2.497	2.497	2.497	2.494
49	2.497	2.497	2.493	2.496	2.496	2.496	2.494
50	2.503	2.501	2.499	2.501	2.501	2.501	2.499
51	2.501	2.500	2.498	2.500	2.500	2.500	2.499
52	2.502	2.500	2.498	2.500	2.500	2.500	2.499
53	2.500	2.500	2.498	2.499	2.499	2.499	2.498
54	2.499	2.498	2.495	2.498	2.498	2.496	2.496
55	2.499	2.499	2.494	2.497	2.497	2.497	2.495
56	2.107	2.107	2.104	2.107	2.107	2.107	2.104
57	2.102	2.102	2.100	2.101	2.102	2.102	2.100
58	2.097	2.097	2.095	2.097	2.097	2.097	2.096
59	2.096	2.096	2.092	2.095	2.095	2.095	2.093
60	2.092	2.092	2.090	2.093	2.093	2.093	2.090
61	2.117	2.117	2.114	2.117	2.116	2.116	2.114
62	2.111	2.111	2.109	2.111	2.111	2.111	2.110
63	2.109	2.109	2.106	2.108	2.108	2.106	2.108
64	2.107	2.107	2.105	2.107	2.107	2.107	2.105
65	2.106	2.106	2.104	2.106	2.106	2.106	2.105
66	2.102	2.102	2.099	2.101	2.101	2.101	2.099
67	2.100	2.100	2.099	2.100	2.100	2.100	2.099
68	2.100	2.100	2.099	2.100	2.100	2.100	2.099
69	2.093	2.093	2.091	2.093	2.093	2.093	2.092
70	2.092	2.092	2.090	2.091	2.091	2.091	2.090
71	2.090	2.090	2.089	2.090	2.090	2.090	2.089
72	2.089	2.089	2.088	2.089	2.089	2.089	2.088

TABLE F7 (continued)

73	2.089	2.089	2.087	2.089	2.089	2.089	2.088
74	2.085	2.085	2.083	2.086	2.085	2.085	2.085
75	2.081	2.081	2.079	2.081	2.080	2.080	2.080
76	2.081	2.081	2.080	2.081	2.081	2.081	2.080
77	2.081	2.082	2.080	2.081	2.081	2.080	2.080
78	2.075	2.075	2.073	2.076	2.075	2.075	2.074
79	2.079	2.079	2.077	2.079	2.078	2.078	2.077
80	2.079	2.079	2.077	2.079	2.078	2.078	2.077
81	2.092	2.091	2.090	2.091	2.091	2.091	2.089
82	2.080	2.080	2.078	2.079	2.079	2.079	2.077
83	2.088	2.088	2.083	2.086	2.086	2.086	2.083
84	2.083	2.083	2.080	2.082	2.082	2.082	2.080
85	2.079	2.079	2.075	2.078	2.078	2.078	2.075
86	2.079	2.078	2.075	2.077	2.077	2.077	2.073
87	2.079	2.078	2.076	2.077	2.078	2.078	2.074
88	2.102	2.101	2.099	2.100	2.100	2.100	2.099
89	2.091	2.090	2.089	2.090	2.090	2.090	2.089
90	2.086	2.085	2.082	2.084	2.084	2.084	2.081
91	2.084	2.083	2.080	2.082	2.082	2.082	2.080
92	2.082	2.082	2.080	2.081	2.081	2.081	2.080
93	2.089	2.088	2.085	2.087	2.087	2.087	2.085
94	1.460	1.460	1.459	1.460	1.460	1.460	1.459
95	1.466	1.466	1.463	1.465	1.465	1.465	1.464
96	1.465	1.465	1.462	1.465	1.465	1.465	1.464
97	1.470	1.470	1.470	1.470	1.471	1.471	1.470
98	1.470	1.470	1.469	1.470	1.470	1.470	1.470
99	1.469	1.469	1.468	1.469	1.469	1.469	1.469
100	1.468	1.468	1.468	1.468	1.468	1.468	1.468
101	1.460	1.460	1.459	1.460	1.460	1.460	1.460
102	1.468	1.468	1.467	1.468	1.468	1.468	1.467
103	1.468	1.468	1.467	1.468	1.468	1.468	1.468
104	1.469	1.469	1.465	1.468	1.468	1.468	1.467
105	1.467	1.467	1.466	1.468	1.468	1.468	1.468
106	1.463	1.463	1.463	1.464	1.464	1.464	1.464
107	2.550	2.549	2.546	2.549	2.549	2.549	2.545
108	2.542	2.541	2.539	2.540	2.541	2.541	2.539
109	2.537	2.535	2.531	2.532	2.532	2.532	2.530
110	2.553	2.552	2.549	2.550	2.551	2.551	2.549
111	2.541	2.541	2.539	2.540	2.540	2.540	2.537
112	2.538	2.535	2.531	2.533	2.533	2.533	2.530
113	2.531	2.531	2.529	2.530	2.530	2.530	2.526
114	2.527	2.525	2.521	2.524	2.524	2.524	2.520
115	2.523	2.521	2.519	2.520	2.520	2.520	2.518
116	2.519	2.519	2.514	2.517	2.517	2.517	2.512
117	2.518	2.516	2.511	2.513	2.513	2.514	2.510
118	2.509	2.509	2.503	2.508	2.508	2.508	2.502
119	2.509	2.508	2.502	2.505	2.505	2.505	2.501
120	2.119	2.119	2.115	2.119	2.118	2.118	2.116
121	2.113	2.113	2.110	2.112	2.112	2.112	2.111
122	2.109	2.109	2.105	2.108	2.108	2.108	2.105
123	2.102	2.103	2.100	2.102	2.102	2.102	2.100
124	2.098	2.099	2.094	2.098	2.098	2.098	2.094
125	2.093	2.093	2.091	2.092	2.092	2.092	2.090
126	2.091	2.091	2.089	2.090	2.090	2.090	2.090
127	2.091	2.091	2.090	2.091	2.091	2.091	2.090
128	2.115	2.116	2.113	2.114	2.114	2.114	2.112
129	2.110	2.110	2.109	2.110	2.110	2.110	2.109
130	2.108	2.109	2.106	2.107	2.107	2.107	2.104
131	2.102	2.102	2.100	2.102	2.102	2.102	2.100
132	2.098	2.098	2.094	2.097	2.097	2.096	2.094
133	2.112	2.112	2.110	2.111	2.111	2.111	2.110
134	2.110	2.110	2.108	2.109	2.109	2.109	2.106
135	2.108	2.108	2.103	2.105	2.105	2.105	2.103
136	2.112	2.112	2.110	2.111	2.111	2.111	2.110
137	2.109	2.108	2.104	2.107	2.107	2.107	2.104
138	2.090	2.090	2.089	2.090	2.090	2.090	2.088
139	2.116	2.116	2.111	2.114	2.114	2.114	2.111
140	2.109	2.109	2.104	2.108	2.108	2.108	2.104
141	2.101	2.101	2.100	2.101	2.100	2.100	2.099
142	2.099	2.098	2.095	2.098	2.098	2.098	2.095
143	2.091	2.091	2.090	2.090	2.090	2.090	2.089
144	2.089	2.088	2.086	2.089	2.089	2.089	2.085
145	2.089	2.089	2.085	2.087	2.087	2.087	2.084
146	2.091	2.091	2.089	2.090	2.090	2.090	2.089
147	2.090	2.090	2.088	2.089	2.089	2.089	2.087
148	2.084	2.084	2.081	2.082	2.082	2.082	2.081
149	2.084	2.084	2.081	2.082	2.082	2.082	2.080

TABLE F7 (continued)

150	2.081	2.081	2.080	2.081	2.081	2.081	2.079	
151	2.081	2.081	2.079	2.080	2.080	2.080	2.079	
152	2.080	2.080	2.079	2.080	2.080	2.080	2.079	
153	2.079	2.079	2.078	2.079	2.079	2.079	2.078	
154	2.078	2.077	2.074	2.076	2.076	2.076	2.073	
155	2.078	2.078	2.074	2.077	2.077	2.077	2.074	
156	2.078	2.078	2.074	2.076	2.076	2.076	2.072	
157	2.091	2.091	2.090	2.090	2.090	2.090	2.089	
158	2.089	2.089	2.084	2.086	2.088	2.086	2.084	
159	2.104	2.103	2.102	2.100	2.102	2.102	2.102	2.099
160	2.100	2.099	2.099	2.095	2.098	2.099	2.098	2.095
161	2.095	2.094	2.093	2.091	2.093	2.093	2.093	2.091
162	2.091	2.090	2.090	2.089	2.090	2.090	2.090	2.088
163	2.089	2.088	2.088	2.085	2.089	2.088	2.088	2.084
164	2.085	2.084	2.083	2.081	2.083	2.083	2.083	2.081
165	2.082	2.082	2.081	2.079	2.081	2.081	2.081	2.079
166	2.078	2.076	2.075	2.073	2.074	2.075	2.075	2.073
167	2.075	2.074	2.074	2.071	2.073	2.074	2.073	2.071
168	2.071	2.070	2.070	2.069	2.069	2.070	2.070	2.069
169	2.070	2.070	2.070	2.069	2.070	2.070	2.070	2.068
170	2.074	2.073	2.073	2.071	2.073	2.073	2.073	2.070
171	2.074	2.073	2.073	2.071	2.072	2.073	2.072	2.070
172	1.451	1.451	1.451	1.450	1.451	1.451	1.451	1.450
173	1.449	1.449	1.449	1.449	1.449	1.449	1.449	1.449
174	1.445	1.445	1.445	1.444	1.445	1.445	1.445	1.444
175	1.444	1.444	1.444	1.443	1.444	1.443	1.443	1.443
176	1.442	1.442	1.442	1.441	1.442	1.442	1.442	1.441
177	1.441	1.441	1.441	1.440	1.441	1.441	1.441	1.441
178	1.440	1.440	1.440	1.440	1.440	1.440	1.440	1.440
179	1.440	1.440	1.440	1.440	1.440	1.440	1.440	1.440
180	1.441	1.441	1.441	1.440	1.441	1.441	1.441	1.441
181	1.442	1.442	1.442	1.441	1.441	1.441	1.441	1.441
182	1.441	1.441	1.441	1.441	1.442	1.442	1.442	1.441
183	1.442	1.442	1.442	1.441	1.442	1.442	1.442	1.442
184	1.442	1.441	1.442	1.441	1.441	1.442	1.441	1.441
185	2.499	2.498	2.498	2.493	2.498	2.498	2.498	2.492
186	2.503	2.503	2.501	2.499	2.501	2.502	2.501	2.499
187	2.503	2.503	2.500	2.499	2.500	2.501	2.500	2.498
188	2.525	2.524	2.522	2.520	2.521	2.522	2.521	2.519
189	2.509	2.509	2.508	2.504	2.508	2.508	2.508	2.503
190	2.553	2.552	2.551	2.549	2.550	2.551	2.550	2.548
191	2.540	2.540	2.539	2.536	2.539	2.539	2.539	2.534
192	2.532	2.531	2.530	2.529	2.530	2.530	2.530	2.526
193	2.514	2.512	2.511	2.510	2.511	2.511	2.511	2.509
194	2.510	2.510	2.509	2.506	2.509	2.509	2.509	2.505
195	2.506	2.506	2.504	2.501	2.502	2.503	2.503	2.500
196	2.503	2.503	2.501	2.500	2.502	2.502	2.503	2.499
197	2.505	2.505	2.503	2.500	2.503	2.503	2.503	2.500
198	2.100	2.100	2.099	2.098	2.099	2.100	2.099	2.096
199	2.097	2.095	2.094	2.092	2.094	2.096	2.095	2.092
200	2.092	2.091	2.091	2.090	2.091	2.092	2.091	2.090
201	2.090	2.090	2.089	2.088	2.089	2.090	2.090	2.088
202	2.089	2.089	2.088	2.087	2.088	2.088	2.088	2.084
203	2.087	2.086	2.085	2.082	2.084	2.085	2.085	2.082
204	2.086	2.085	2.084	2.081	2.084	2.084	2.084	2.081
205	2.084	2.084	2.083	2.080	2.082	2.083	2.083	2.080
206	2.084	2.082	2.082	2.080	2.082	2.082	2.082	2.080
207	2.080	2.080	2.080	2.079	2.080	2.080	2.080	2.078
208	2.080	2.080	2.080	2.078	2.079	2.080	2.080	2.079
209	2.080	2.080	2.079	2.076	2.079	2.079	2.079	2.076
210	2.076	2.075	2.074	2.072	2.073	2.074	2.074	2.071
211	2.079	2.079	2.078	2.075	2.078	2.078	2.078	2.075
212	2.080	2.079	2.079	2.078	2.079	2.080	2.079	2.077
213	2.079	2.079	2.078	2.078	2.079	2.078	2.078	2.076
214	2.080	2.080	2.079	2.077	2.079	2.079	2.079	2.075
215	2.079	2.079	2.079	2.077	2.078	2.079	2.079	2.077
216	2.101	2.101	2.100	2.098	2.099	2.100	2.100	2.098
217	2.098	2.097	2.095	2.093	2.096	2.097	2.097	2.092
218	2.093	2.092	2.091	2.090	2.091	2.092	2.092	2.090
219	2.090	2.090	2.089	2.088	2.089	2.089	2.089	2.088
220	2.088	2.088	2.086	2.083	2.087	2.087	2.087	2.083
221	2.087	2.086	2.084	2.082	2.085	2.085	2.084	2.082
222	2.083	2.083	2.081	2.080	2.082	2.082	2.082	2.080
223	2.080	2.079	2.079	2.077	2.079	2.079	2.079	2.077
224	2.073	2.073	2.071	2.070	2.071	2.071	2.071	2.070
225	2.073	2.072	2.071	2.070	2.073	2.072	2.072	2.070
226	2.072	2.071	2.070	2.069	2.070	2.070	2.070	2.069

TABLE F7 (continued)

227	2.073	2.073	2.072	2.070	2.072	2.072	2.072	2.070
228	2.074	2.073	2.072	2.071	2.072	2.072	2.072	2.071
229	2.069	2.069	2.068	2.065	2.068	2.068	2.068	2.064
230	2.070	2.069	2.069	2.067	2.069	2.069	2.069	2.067
231	2.070	2.070	2.069	2.067	2.069	2.069	2.069	2.067
232	2.074	2.074	2.073	2.071	2.072	2.072	2.072	2.071
233	2.075	2.075	2.074	2.072	2.074	2.074	2.074	2.071
234	2.077	2.077	2.075	2.073	2.075	2.075	2.075	2.072
235	2.077	2.077	2.075	2.072	2.074	2.074	2.074	2.072
236	2.078	2.077	2.076	2.073	2.077	2.075	2.077	2.073
237	2.073	2.073	2.073	2.070	2.073	2.072	2.072	2.070
238	2.070	2.070	2.069	2.068	2.070	2.069	2.070	2.068
239	2.069	2.069	2.068	2.065	2.068	2.066	2.068	2.065
240	2.067	2.067	2.066	2.063	2.066	2.067	2.067	2.063
241	2.073	2.073	2.071	2.070	2.072	2.072	2.072	2.070
242	2.072	2.072	2.071	2.070	2.071	2.072	2.072	2.070
243	2.073	2.073	2.071	2.070	2.072	2.072	2.072	2.070
244	2.073	2.072	2.072	2.070	2.071	2.072	2.072	2.070
245	2.073	2.073	2.072	2.071	2.071	2.073	2.073	2.070
246	2.073	2.073	2.072	2.070	2.072	2.073	2.072	2.070
247	2.073	2.073	2.072	2.071	2.072	2.073	2.072	2.070
248	2.074	2.074	2.073	2.071	2.073	2.073	2.073	2.071
249	2.074	2.074	2.073	2.071	2.073	2.073	2.073	2.071
250	1.444	1.444	1.444	1.443	1.444	1.444	1.444	1.444
251	1.443	1.443	1.443	1.442	1.443	1.444	1.443	1.442
252	1.443	1.443	1.443	1.442	1.443	1.443	1.443	1.442
253	1.442	1.442	1.442	1.441	1.442	1.442	1.442	1.442
254	1.442	1.442	1.442	1.441	1.441	1.442	1.442	1.442
255	1.440	1.440	1.440	1.439	1.440	1.440	1.440	1.440
256	1.440	1.440	1.440	1.439	1.440	1.440	1.440	1.440
257	1.440	1.440	1.440	1.440	1.440	1.440	1.440	1.440
258	1.440	1.440	1.440	1.439	1.440	1.440	1.440	1.440
259	1.439	1.439	1.439	1.438	1.439	1.439	1.439	1.436
260	1.439	1.439	1.439	1.438	1.439	1.439	1.439	1.439
261	1.439	1.439	1.439	1.438	1.439	1.439	1.439	1.439
262	1.439	1.439	1.439	1.439	1.439	1.439	1.439	1.439
263	2.509	2.509	2.507	2.504	2.508	2.508	2.508	2.503
264	2.510	2.510	2.509	2.505	2.509	2.509	2.509	2.504
265	2.513	2.513	2.511	2.509	2.511	2.512	2.512	2.509
266	2.514	2.513	2.512	2.510	2.512	2.513	2.512	2.509
267	2.516	2.514	2.512	2.510	2.513	2.513	2.513	2.510
268	2.516	2.515	2.514	2.511	2.513	2.513	2.513	2.510
269	2.515	2.514	2.513	2.511	2.513	2.514	2.514	2.510
270	2.518	2.518	2.515	2.513	2.515	2.517	2.516	2.512
271	2.518	2.518	2.517	2.513	2.517	2.517	2.517	2.512
272	2.518	2.518	2.517	2.514	2.517	2.516	2.517	2.513
273	2.519	2.518	2.517	2.514	2.517	2.516	2.517	2.513
274	2.515	2.515	2.513	2.512	2.513	2.514	2.513	2.510
275	2.518	2.516	2.514	2.512	2.514	2.515	2.515	2.510
276	2.118	2.118	2.117	2.114	2.117	2.116	2.118	2.113
277	2.114	2.113	2.113	2.111	2.112	2.113	2.113	2.111
278	2.114	2.113	2.112	2.111	2.112	2.112	2.112	2.110
279	2.112	2.112	2.110	2.109	2.110	2.110	2.110	2.109
280	2.111	2.110	2.110	2.108	2.110	2.110	2.110	2.108
281	2.110	2.109	2.108	2.106	2.109	2.108	2.109	2.107
282	2.107	2.107	2.106	2.104	2.106	2.107	2.106	2.103
283	2.101	2.101	2.100	2.098	2.100	2.101	2.100	2.098
284	2.101	2.101	2.100	2.099	2.100	2.100	2.100	2.098
285	2.102	2.101	2.109	2.099	2.100	2.100	2.100	2.099
286	2.103	2.103	2.102	2.100	2.102	2.102	2.102	2.100
287	2.104	2.104	2.103	2.101	2.102	2.104	2.103	2.101
288	2.104	2.104	2.103	2.101	2.103	2.104	2.104	2.101
289	2.104	2.103	2.102	2.100	2.102	2.102	2.102	2.100
290	2.106	2.105	2.105	2.101	2.103	2.104	2.104	2.101
291	2.104	2.104	2.102	2.101	2.102	2.102	2.102	2.101
292	2.104	2.104	2.102	2.100	2.101	2.103	2.102	2.100
293	2.128	2.128	2.127	2.124	2.127	2.127	2.127	2.123
294	2.123	2.123	2.122	2.120	2.121	2.122	2.122	2.120
295	2.117	2.116	2.114	2.112	2.113	2.113	2.113	2.111
296	2.120	2.120	2.119	2.117	2.118	2.119	2.119	2.117
297	2.111	2.111	2.111	2.111	2.111	2.111	2.111	2.109
298	2.102	2.101	2.101	2.099	2.100	2.101	2.101	2.099
299	2.102	2.101	2.101	2.099	2.100	2.101	2.100	2.099
300	2.100	2.100	2.099	2.098	2.099	2.100	2.100	2.097
301	2.100	2.100	2.099	2.097	2.099	2.100	2.099	2.097
302	2.093	2.092	2.091	2.090	2.091	2.091	2.091	2.089
303	2.093	2.092	2.092	2.090	2.091	2.091	2.091	2.089

TABLE F7 (continued)

304	2.089	2.090	2.089	2.087	2.089	2.089	2.089	2.086
305	2.090	2.090	2.089	2.088	2.089	2.089	2.089	2.086
306	2.089	2.089	2.089	2.087	2.089	2.089	2.089	2.085
307	2.081	2.081	2.080	2.079	2.080	2.080	2.080	2.079
308	2.082	2.081	2.081	2.079	2.080	2.081	2.081	2.079
309	2.082	2.081	2.081	2.080	2.081	2.081	2.081	2.079
310	2.084	2.082	2.082	2.080	2.081	2.081	2.081	2.080
311	2.085	2.085	2.083	2.081	2.083	2.084	2.084	2.081
312	2.085	2.085	2.083	2.081	2.083	2.083	2.083	2.080
313	2.084	2.084	2.083	2.081	2.083	2.083	2.083	2.081
314	2.085	2.082	2.083	2.081	2.083	2.083	2.083	2.080
315	2.048	2.048	2.046	2.043	2.047	2.047	2.047	2.044
316	2.049	2.049	2.047	2.045	2.048	2.048	2.048	2.044
317	2.049	2.049	2.048	2.046	2.049	2.049	2.049	2.047
318	2.050	2.049	2.049	2.047	2.049	2.049	2.049	2.048
319	2.050	2.050	2.049	2.049	2.050	2.050	2.050	2.049
320	2.051	2.050	2.050	2.049	2.050	2.050	2.050	2.049
321	2.051	2.051	2.050	2.049	2.050	2.050	2.050	2.049
322	2.053	2.053	2.051	2.050	2.052	2.052	2.052	2.050
323	2.053	2.054	2.052	2.051	2.052	2.052	2.052	2.050
324	2.055	2.054	2.052	2.051	2.053	2.053	2.053	2.051
325	2.053	2.053	2.052	2.051	2.053	2.053	2.053	2.051
326	2.059	2.059	2.057	2.054	2.058	2.058	2.058	2.055
327	2.060	2.059	2.058	2.058	2.059	2.059	2.059	2.057
328	1.446	1.446	1.446	1.444	1.446	1.447	1.447	1.447
329	1.446	1.446	1.446	1.446	1.447	1.447	1.447	1.446
330	1.446	1.446	1.446	1.444	1.446	1.446	1.446	1.446
331	1.447	1.447	1.447	1.444	1.446	1.446	1.446	1.446
332	1.445	1.445	1.445	1.444	1.446	1.446	1.446	1.446
333	1.446	1.445	1.445	1.444	1.445	1.446	1.446	1.446
334	1.446	1.446	1.446	1.444	1.446	1.446	1.446	1.445
335	1.444	1.444	1.444	1.443	1.444	1.444	1.444	1.444
336	1.445	1.445	1.445	1.443	1.444	1.444	1.444	1.444
337	1.445	1.445	1.445	1.445	1.445	1.445	1.445	1.445
338	1.444	1.444	1.444	1.443	1.444	1.444	1.444	1.443
339	1.445	1.445	1.446	1.444	1.445	1.445	1.445	1.445
340	1.445	1.445	1.445	1.445	1.445	1.445	1.445	1.445
341	2.509	2.507	2.504	2.502	2.504	2.504	2.504	2.501
342	2.499	2.499	2.497	2.494	2.497	2.498	2.497	2.493
343	2.493	2.493	2.491	2.490	2.492	2.492	2.491	2.489
344	2.487	2.485	2.482	2.480	2.483	2.483	2.483	2.480
345	2.482	2.481	2.480	2.479	2.480	2.480	2.480	2.479
346	2.480	2.480	2.479	2.476	2.479	2.479	2.479	2.477
347	2.479	2.479	2.477	2.474	2.478	2.478	2.478	2.474
348	2.472	2.472	2.470	2.469	2.471	2.471	2.471	2.469
349	2.472	2.472	2.471	2.469	2.471	2.471	2.471	2.469
350	2.473	2.472	2.471	2.469	2.471	2.471	2.471	2.469
351	2.473	2.472	2.471	2.470	2.471	2.471	2.471	2.469
352	2.474	2.473	2.472	2.470	2.473	2.472	2.473	2.470
353	2.477	2.476	2.473	2.471	2.474	2.474	2.474	2.471
354	2.080	2.080	2.080	2.079	2.081	2.081	2.081	2.079
355	2.078	2.079	2.078	2.076	2.078	2.079	2.078	2.077
356	2.078	2.077	2.074	2.073	2.077	2.077	2.077	2.074
357	2.072	2.072	2.072	2.071	2.072	2.072	2.072	2.071
358	2.071	2.071	2.071	2.070	2.071	2.071	2.071	2.070
359	2.070	2.070	2.069	2.068	2.070	2.070	2.069	2.068
360	2.069	2.069	2.069	2.066	2.069	2.069	2.069	2.068
361	2.064	2.064	2.064	2.062	2.064	2.064	2.064	2.063
362	2.067	2.067	2.066	2.064	2.068	2.068	2.068	2.065
363	2.066	2.066	2.064	2.063	2.066	2.066	2.066	2.063
364	2.061	2.061	2.060	2.060	2.061	2.061	2.061	2.060
365	2.062	2.062	2.061	2.060	2.062	2.062	2.062	2.061
366	2.063	2.063	2.062	2.061	2.062	2.062	2.062	2.061
367	2.044	2.044	2.042	2.041	2.042	2.042	2.042	2.041
368	2.047	2.047	2.044	2.043	2.044	2.044	2.044	2.043
369	2.048	2.047	2.047	2.044	2.047	2.047	2.047	2.046
370	2.049	2.049	2.048	2.046	2.048	2.048	2.048	2.047
371	2.049	2.049	2.048	2.047	2.049	2.049	2.049	2.048
372	2.051	2.050	2.050	2.049	2.050	2.050	2.050	2.049
373	2.051	2.051	2.050	2.049	2.051	2.051	2.051	2.050
374	2.051	2.051	2.050	2.049	2.050	2.050	2.050	2.049
375	2.050	2.050	2.049	2.048	2.049	2.049	2.049	2.048
376	2.049	2.049	2.048	2.047	2.049	2.049	2.049	2.048
377	2.050	2.050	2.049	2.048	2.049	2.050	2.050	2.049
378	2.049	2.049	2.049	2.048	2.049	2.049	2.049	2.049
379	2.051	2.051	2.049	2.049	2.050	2.050	2.050	2.049
380	2.073	2.073	2.071	2.070	2.071	2.072	2.072	2.071

TABLE F7 (continued)

381	2.070	2.070	2.070	2.069	2.070	2.070	2.070	2.069
382	2.067	2.069	2.067	2.064	2.068	2.067	2.067	2.064
383	2.064	2.064	2.062	2.061	2.063	2.063	2.063	2.061
384	2.062	2.062	2.061	2.060	2.061	2.061	2.061	2.060
385	2.059	2.059	2.059	2.057	2.059	2.056	2.058	2.058
386	2.059	2.059	2.058	2.054	2.059	2.056	2.058	2.055
387	2.059	2.058	2.058	2.054	2.058	2.056	2.057	2.055
388	2.057	2.057	2.055	2.052	2.054	2.055	2.054	2.053
389	2.056	2.054	2.054	2.051	2.053	2.053	2.053	2.051
390	2.049	2.049	2.048	2.047	2.049	2.049	2.049	2.048
391	2.049	2.049	2.049	2.048	2.049	2.049	2.049	2.047
392	2.049	2.049	2.048	2.047	2.049	2.049	2.048	2.047
393	2.057	2.056	2.053	2.052	2.054	2.054	2.054	2.053
394	2.059	2.059	2.058	2.054	2.059	2.059	2.059	2.056
395	2.060	2.060	2.059	2.057	2.059	2.059	2.059	2.058
396	2.061	2.061	2.060	2.059	2.061	2.061	2.061	2.059
397	2.061	2.061	2.060	2.059	2.061	2.061	2.061	2.059
398	2.064	2.064	2.062	2.061	2.063	2.063	2.063	2.061
399	2.067	2.067	2.064	2.062	2.064	2.064	2.064	2.062
400	2.068	2.068	2.068	2.063	2.067	2.067	2.067	2.064
401	2.069	2.069	2.068	2.065	2.068	2.066	2.068	2.067
402	2.069	2.069	2.068	2.067	2.069	2.069	2.069	2.067
403	2.070	2.070	2.069	2.068	2.069	2.070	2.069	2.068
404	2.070	2.070	2.069	2.068	2.069	2.070	2.069	2.066
405	2.070	2.069	2.068	2.066	2.069	2.066	2.068	2.067
406	2.480	2.480	2.479	2.477	2.479	2.479	2.479	2.478
407	2.484	2.483	2.480	2.479	2.481	2.481	2.481	2.479
408	2.486	2.483	2.482	2.480	2.483	2.483	2.483	2.481
409	2.488	2.487	2.483	2.482	2.485	2.485	2.484	2.482
410	2.489	2.489	2.487	2.483	2.488	2.486	2.488	2.483
411	2.489	2.489	2.487	2.483	2.489	2.489	2.488	2.484
412	2.489	2.489	2.488	2.483	2.488	2.486	2.488	2.483
413	2.490	2.489	2.487	2.483	2.488	2.486	2.488	2.484
414	2.490	2.490	2.489	2.487	2.490	2.490	2.490	2.487
415	2.491	2.491	2.490	2.487	2.490	2.490	2.490	2.488
416	2.492	2.492	2.490	2.489	2.491	2.490	2.490	2.489
417	2.494	2.493	2.491	2.490	2.492	2.491	2.491	2.489
418	2.494	2.493	2.491	2.491	2.492	2.491	2.492	2.490
419	1.458	1.458	1.459	1.456	1.458	1.458	1.458	1.458
420	1.455	1.455	1.454	1.453	1.455	1.455	1.455	1.455
421	1.453	1.453	1.453	1.452	1.453	1.453	1.453	1.453
422	1.451	1.451	1.451	1.450	1.451	1.451	1.451	1.451
423	1.451	1.450	1.450	1.450	1.450	1.450	1.450	1.450
424	1.449	1.449	1.449	1.448	1.448	1.448	1.448	1.448
425	1.449	1.449	1.449	1.448	1.448	1.446	1.448	1.448
426	1.448	1.448	1.448	1.447	1.448	1.448	1.448	1.448
427	1.446	1.446	1.446	1.444	1.445	1.445	1.445	1.445
428	1.442	1.442	1.442	1.441	1.442	1.442	1.442	1.442
429	1.443	1.443	1.443	1.442	1.443	1.443	1.443	1.443
430	1.443	1.443	1.443	1.441	1.442	1.442	1.442	1.443
431	1.442	1.443	1.442	1.442	1.442	1.442	1.442	1.442
432	2.063	2.063	2.062	2.061	2.062	2.063	2.063	2.061
433	2.063	2.063	2.062	2.061	2.062	2.063	2.063	2.061
434	2.065	2.065	2.063	2.063	2.064	2.064	2.063	2.061
435	2.063	2.063	2.062	2.061	2.063	2.062	2.062	2.061
436	2.063	2.063	2.062	2.060	2.062	2.062	2.062	2.061
437	2.061	2.061	2.061	2.060	2.061	2.061	2.061	2.060
438	2.058	2.058	2.056	2.054	2.058	2.058	2.058	2.054
439	2.058	2.058	2.058	2.054	2.058	2.058	2.058	2.055
440	2.059	2.059	2.057	2.054	2.057	2.057	2.057	2.054
441	2.058	2.059	2.057	2.054	2.058	2.058	2.058	2.054
442	2.059	2.059	2.057	2.055	2.058	2.058	2.058	2.055
443	2.059	2.059	2.058	2.056	2.058	2.058	2.058	2.057
444	2.059	2.059	2.058	2.056	2.059	2.059	2.059	2.057
445	2.031	2.030	2.030	2.029	2.030	2.030	2.030	2.030
446	2.034	2.034	2.032	2.031	2.032	2.032	2.032	2.031
447	2.038	2.038	2.036	2.034	2.037	2.036	2.038	2.034
448	2.040	2.040	2.040	2.038	2.040	2.040	2.040	2.039
449	2.042	2.042	2.041	2.039	2.041	2.041	2.041	2.040
450	2.047	2.046	2.044	2.042	2.044	2.045	2.045	2.043
451	2.048	2.048	2.047	2.044	2.047	2.047	2.047	2.044
452	2.049	2.049	2.047	2.046	2.048	2.048	2.048	2.047
453	2.050	2.050	2.049	2.048	2.049	2.049	2.049	2.048
454	2.051	2.051	2.050	2.049	2.051	2.051	2.051	2.049
455	2.051	2.051	2.050	2.049	2.051	2.051	2.051	2.049
456	2.051	2.051	2.050	2.049	2.051	2.051	2.051	2.049
457	2.051	2.051	2.050	2.049	2.050	2.050	2.050	2.049

TABLE F7 (continued)

458	2.522	2.521	2.520	2.518	2.519	2.520	2.519	2.513
459	2.522	2.521	2.520	2.518	2.519	2.520	2.520	2.513
460	2.522	2.520	2.519	2.518	2.519	2.520	2.519	2.513
461	2.522	2.521	2.520	2.518	2.519	2.521	2.520	2.514
462	2.522	2.522	2.521	2.518	2.519	2.521	2.520	2.514
463	2.526	2.524	2.523	2.520	2.521	2.522	2.522	2.517
464	2.527	2.524	2.523	2.521	2.522	2.523	2.523	2.518
465	2.527	2.526	2.523	2.520	2.522	2.524	2.523	2.518
466	2.528	2.526	2.524	2.521	2.522	2.524	2.524	2.518
467	2.528	2.528	2.526	2.522	2.522	2.525	2.524	2.519
468	2.527	2.527	2.524	2.520	2.522	2.524	2.523	2.518
469	2.526	2.525	2.523	2.520	2.521	2.522	2.522	2.518
470	2.523	2.522	2.521	2.519	2.520	2.521	2.521	2.515
471	2.537	2.536	2.533	2.530	2.531	2.534	2.533	2.528
472	2.535	2.534	2.532	2.530	2.531	2.532	2.532	2.528
473	2.531	2.531	2.529	2.527	2.529	2.530	2.529	2.521
474	2.531	2.530	2.530	2.527	2.528	2.530	2.529	2.522
475	2.530	2.530	2.529	2.525	2.527	2.529	2.529	2.521
476	2.529	2.529	2.528	2.524	2.525	2.529	2.528	2.520
477	2.529	2.529	2.528	2.523	2.524	2.528	2.527	2.520
478	2.529	2.528	2.527	2.523	2.523	2.526	2.526	2.520
479	2.528	2.528	2.525	2.522	2.523	2.526	2.524	2.519
480	2.521	2.521	2.520	2.518	2.519	2.520	2.520	2.514
481	2.522	2.521	2.520	2.518	2.519	2.520	2.520	2.513
482	2.521	2.521	2.520	2.518	2.518	2.521	2.520	2.513
483	2.522	2.522	2.520	2.518	2.519	2.521	2.520	2.514
484	2.429	2.428	2.427	2.422	2.426	2.425	2.425	2.420
485	2.429	2.428	2.427	2.423	2.424	2.426	2.425	2.420
486	2.429	2.429	2.427	2.423	2.425	2.427	2.426	2.420
487	2.429	2.428	2.424	2.422	2.425	2.425	2.424	2.420
488	2.429	2.427	2.424	2.422	2.424	2.424	2.424	2.420
489	2.428	2.427	2.423	2.422	2.423	2.424	2.424	2.429
490	2.427	2.425	2.424	2.422	2.423	2.424	2.423	2.429
491	2.426	2.424	2.423	2.420	2.422	2.423	2.423	2.429
492	2.426	2.424	2.423	2.421	2.422	2.423	2.422	2.429
493	2.422	2.422	2.420	2.429	2.420	2.420	2.420	2.425
494	2.423	2.423	2.421	2.429	2.420	2.421	2.421	2.427
495	2.424	2.422	2.421	2.429	2.421	2.421	2.421	2.427
496	2.423	2.422	2.420	2.429	2.420	2.420	2.420	2.425
497	1.871	1.871	1.871	1.870	1.870	1.870	1.870	1.869
498	1.871	1.871	1.871	1.870	1.870	1.870	1.870	1.869
499	1.871	1.871	1.871	1.870	1.870	1.870	1.870	1.869
500	1.871	1.871	1.870	1.869	1.870	1.870	1.870	1.869
501	1.871	1.871	1.870	1.869	1.870	1.870	1.870	1.869
502	1.871	1.871	1.870	1.869	1.870	1.870	1.870	1.869
503	1.869	1.869	1.868	1.867	1.868	1.868	1.868	1.866
504	1.869	1.869	1.869	1.867	1.868	1.868	1.869	1.867
505	1.869	1.869	1.869	1.867	1.869	1.869	1.869	1.867
506	1.870	1.870	1.869	1.867	1.869	1.869	1.869	1.867
507	1.870	1.870	1.869	1.868	1.869	1.869	1.869	1.867
508	1.869	1.869	1.869	1.868	1.869	1.869	1.869	1.866
509	1.870	1.870	1.869	1.867	1.869	1.869	1.869	1.868
510	2.434	2.434	2.432	2.430	2.431	2.432	2.432	2.426
511	2.436	2.434	2.433	2.430	2.432	2.434	2.433	2.429
512	2.437	2.437	2.433	2.430	2.433	2.434	2.434	2.429
513	2.437	2.437	2.434	2.431	2.433	2.434	2.434	2.430
514	2.437	2.436	2.434	2.432	2.433	2.434	2.434	2.430
515	2.438	2.436	2.434	2.432	2.434	2.434	2.434	2.430
516	2.438	2.437	2.434	2.432	2.433	2.436	2.434	2.430
517	2.438	2.437	2.434	2.432	2.433	2.434	2.434	2.430
518	2.438	2.437	2.434	2.432	2.433	2.434	2.434	2.430
519	2.439	2.439	2.437	2.434	2.436	2.437	2.436	2.400
520	2.439	2.438	2.437	2.433	2.436	2.438	2.437	2.410
521	2.439	2.439	2.438	2.434	2.436	2.436	2.437	2.410
522	2.439	2.439	2.438	2.434	2.436	2.439	2.437	2.410
523	2.603	2.602	2.602	2.599	2.600	2.601	2.601	2.594
524	2.604	2.602	2.602	2.599	1.601	2.602	2.601	2.596
525	2.603	2.602	2.601	2.599	2.600	2.601	2.601	2.594
526	2.602	2.601	2.600	2.597	2.598	2.600	2.599	2.593
527	2.601	2.601	2.600	2.598	2.599	2.600	2.599	2.592
528	2.601	2.601	2.600	2.598	2.599	2.600	2.599	2.592
529	2.601	2.600	2.600	2.597	2.599	2.600	2.599	2.592
530	2.601	2.600	2.600	2.596	2.599	2.601	2.600	2.593
531	2.602	2.601	2.600	2.598	2.599	2.600	2.600	2.593
532	2.602	2.601	2.600	2.598	2.599	2.601	2.600	2.594
533	2.602	2.601	2.600	2.598	2.599	2.600	2.600	2.594
534	2.602	2.601	2.600	2.598	2.599	2.601	2.599	2.594

TABLE F7 (continued)

535	2.602	2.601	2.600	2.598	2.599	2.600	2.599	2.593
536	2.154	2.154	2.153	2.152	2.153	2.155	2.154	2.156
537	2.156	2.154	2.154	2.152	2.153	2.155	2.154	2.152
538	2.154	2.154	2.153	2.151	2.153	2.156	2.153	2.151
539	2.154	2.154	2.153	2.151	2.153	2.154	2.153	2.152
540	2.154	2.153	2.153	2.151	2.152	2.154	2.153	2.152
541	2.157	2.154	2.154	2.151	2.154	2.154	2.154	2.152
542	2.157	2.155	2.155	2.153	2.154	2.157	2.155	2.153
543	2.157	2.156	2.156	2.154	2.155	2.157	2.157	2.154
544	4.898	4.921	4.881	4.918	4.929	4.890	4.909	4.916
545	4.905	4.930	4.889	4.923	4.935	4.899	4.915	4.923
546	4.910	4.935	4.892	4.929	4.940	4.901	4.920	4.928
547	4.911	4.939	4.894	4.930	4.942	4.903	4.921	4.930
548	4.910	4.937	4.894	4.930	4.941	4.901	4.920	4.921
549	1.910	1.910	1.910	1.909	1.909	1.910	1.910	1.908
550	1.911	1.911	1.911	1.909	1.910	1.910	1.910	1.909
551	1.912	1.912	1.911	1.910	1.911	1.912	1.912	1.910
552	1.917	1.915	1.913	1.912	1.914	1.914	1.914	1.912
553	1.917	1.917	1.914	1.913	1.914	1.915	1.915	1.913
554	1.918	1.918	1.916	1.914	1.916	1.916	1.916	1.913
555	1.919	1.918	1.917	1.914	1.917	1.917	1.917	1.914
556	2.271	2.272	2.270	2.269	2.270	2.270	2.270	2.267
557	2.272	2.272	2.270	2.270	2.271	2.271	2.271	2.268
558	2.273	2.274	2.271	2.270	2.271	2.271	2.271	2.269
559	2.274	2.274	2.272	2.271	2.272	2.273	2.271	2.270
560	2.275	2.275	2.272	2.271	2.273	2.273	2.273	2.270
561	2.275	2.275	2.272	2.271	2.273	2.273	2.273	2.270
562	2.275	2.275	2.273	2.272	2.273	2.273	2.273	2.270
563	2.271	2.270	2.270	2.268	2.269	2.270	2.270	2.265
564	2.271	2.271	2.271	2.269	2.269	2.271	2.270	2.267
565	2.272	2.272	2.271	2.269	2.270	2.271	2.271	2.268
566	2.273	2.273	2.273	2.270	2.270	2.273	2.273	2.268
567	2.274	2.274	2.273	2.270	2.271	2.273	2.273	2.269
568	2.696	2.696	2.691	2.691	2.693	2.692	2.692	2.689
569	2.700	2.700	2.696	2.697	2.698	2.698	2.698	2.693
570	2.702	2.703	2.699	2.699	2.701	2.700	2.700	2.697
571	2.705	2.705	2.700	2.701	2.703	2.702	2.702	2.699
572	2.709	2.709	2.703	2.703	2.706	2.705	2.706	2.701
573	2.711	2.712	2.708	2.709	2.710	2.709	2.709	2.704
574	2.713	2.713	2.709	2.709	2.711	2.710	2.710	2.716
575	2.713	2.714	2.710	2.710	2.711	2.711	2.711	2.708
576	3.158	3.158	3.151	3.152	3.153	3.153	3.153	3.148
577	3.159	3.159	3.152	3.153	3.156	3.154	3.154	3.149
578	3.159	3.160	3.153	3.154	3.153	3.156	3.156	3.150
579	3.160	3.160	3.154	3.154	3.158	3.156	3.155	3.151
580	3.160	3.161	3.155	3.157	3.159	3.156	3.158	3.152
581	3.162	3.162	3.157	3.158	3.160	3.156	3.158	3.153
582	3.163	3.163	3.158	3.158	3.160	3.159	3.159	3.154
583	3.163	3.163	3.159	3.159	3.161	3.160	3.160	3.154
584	2.944	2.944	2.938	2.938	2.940	2.939	2.940	2.934
585	2.947	2.945	2.939	2.939	2.941	2.940	2.940	2.937
586	2.943	2.942	2.935	2.934	2.938	2.937	2.937	2.932
587	2.942	2.941	2.934	2.934	2.937	2.935	2.935	2.931
588	2.940	2.939	2.932	2.932	2.933	2.933	2.933	2.930
589	4.369	4.367	4.353	4.354	4.356	4.355	4.357	4.348
590	4.369	4.367	4.353	4.354	4.359	4.356	4.357	4.349
591	4.368	4.365	4.353	4.354	4.358	4.354	4.357	4.348
592	4.367	4.364	4.352	4.353	4.358	4.353	4.354	4.347
593	4.367	4.364	4.350	4.353	4.356	4.353	4.353	4.346
594	4.369	4.367	4.353	4.355	4.359	4.356	4.358	4.348
595	6.582	6.582	6.556	6.563	6.567	6.559	6.561	6.545
596	6.582	6.581	6.558	6.562	6.564	6.558	6.561	6.541
597	6.580	6.580	6.557	6.561	6.563	6.555	6.559	6.541
598	6.581	6.580	6.557	6.561	6.564	6.558	6.560	6.540
599	3.725	3.727	3.716	3.719	3.721	3.718	3.720	3.711
600	3.727	3.728	3.718	3.720	3.722	3.719	3.720	3.713
601	3.728	3.729	3.718	3.720	3.722	3.720	3.721	3.713
602	3.729	3.729	3.719	3.721	3.723	3.721	3.721	3.714
603	3.731	3.732	3.721	3.724	3.728	3.725	3.726	3.719
604	3.733	3.734	3.723	3.728	3.729	3.727	3.728	3.720
605	3.172	3.174	3.167	3.169	3.171	3.169	3.170	3.164
606	3.173	3.177	3.168	3.170	3.173	3.169	3.171	3.166
607	3.174	3.178	3.169	3.171	3.174	3.170	3.172	3.167
608	3.174	3.177	3.169	3.172	3.174	3.170	3.172	3.168
609	3.175	3.177	3.169	3.172	3.176	3.171	3.173	3.168
610	3.176	3.178	3.170	3.172	3.176	3.171	3.173	3.168
611	4.030	4.033	4.020	4.025	4.029	4.023	4.026	4.018

TABLE F7 (continued)

612	4.032	4.036	4.022	4.028	4.031	4.026	4.029	4.020
613	4.033	4.038	4.024	4.029	4.032	4.028	4.030	4.021
614	4.034	4.038	4.025	4.030	4.033	4.029	4.030	4.022
615	4.036	4.039	4.027	4.030	4.034	4.029	4.031	4.022
616	4.039	4.041	4.029	4.032	4.038	4.031	4.033	4.026
617	4.799	4.802	4.785	4.792	4.798	4.789	4.791	4.781
618	4.800	4.802	4.788	4.793	4.799	4.790	4.793	4.783
619	4.801	4.805	4.789	4.796	4.800	4.792	4.796	4.785
620	4.803	4.808	4.790	4.798	4.801	4.794	4.798	4.788
621	4.806	4.810	4.793	4.800	4.803	4.796	4.800	4.790
622	4.809	4.812	4.796	4.802	4.807	4.799	4.801	4.792
623	7.270	7.277	7.248	7.268	7.268	7.259	7.258	7.238
624	7.283	7.291	7.261	7.280	7.280	7.266	7.270	7.250
625	7.288	7.295	7.264	7.284	7.284	7.269	7.274	7.253
626	7.291	7.299	7.269	7.289	7.289	7.273	7.279	7.258
627	7.294	7.302	7.272	7.292	7.292	7.276	7.281	7.261
628	7.300	7.309	7.279	7.298	7.298	7.282	7.288	7.267
629	3.581	3.583	3.573	3.580	3.581	3.577	3.579	3.571
630	3.582	3.584	3.574	3.581	3.582	3.576	3.580	3.573
631	3.583	3.586	3.577	3.583	3.583	3.579	3.581	3.574
632	3.584	3.586	3.577	3.583	3.583	3.579	3.581	3.574
633	3.585	3.587	3.578	3.583	3.586	3.580	3.582	3.576
634	3.584	3.586	3.578	3.584	3.586	3.580	3.582	3.577
635	3.510	3.510	3.507	3.510	3.510	3.506	3.510	3.502
636	3.512	3.513	3.508	3.512	3.512	3.510	3.512	3.503
637	3.513	3.514	3.509	3.512	3.513	3.510	3.512	3.504
638	3.513	3.517	3.510	3.513	3.514	3.511	3.512	3.506
639	3.514	3.517	3.510	3.513	3.514	3.511	3.513	3.507
640	3.516	3.518	3.510	3.514	3.517	3.513	3.515	3.506
641	3.947	3.949	3.940	3.945	3.946	3.943	3.944	3.934
642	3.948	3.950	3.941	3.948	3.949	3.944	3.947	3.938
643	3.948	3.950	3.942	3.948	3.946	3.944	3.948	3.938
644	3.949	3.951	3.943	3.949	3.950	3.945	3.946	3.938
645	3.949	3.950	3.942	3.949	3.949	3.945	3.948	3.939
646	3.950	3.952	3.943	3.949	3.950	3.947	3.948	3.939
647	4.639	4.640	4.630	4.637	4.638	4.633	4.637	4.622
648	4.639	4.641	4.631	4.638	4.639	4.633	4.638	4.623
649	4.639	4.640	4.631	4.638	4.639	4.633	4.637	4.623
650	4.639	4.641	4.631	4.638	4.639	4.633	4.637	4.623
651	4.640	4.642	4.632	4.639	4.640	4.634	4.638	4.623
652	4.640	4.643	4.632	4.640	4.640	4.635	4.639	4.624
653	5.459	5.463	5.451	5.459	5.459	5.453	5.458	5.440
654	5.462	5.466	5.452	5.461	5.460	5.454	5.459	5.441
655	5.462	5.467	5.452	5.461	5.461	5.455	5.459	5.442
656	5.462	5.467	5.454	5.460	5.461	5.455	5.459	5.442
657	5.463	5.468	5.453	5.462	5.461	5.456	5.460	5.443
658	5.463	5.467	5.453	5.462	5.462	5.457	5.460	5.443
659	8.354	8.360	8.339	8.352	8.351	8.342	8.344	8.311
660	8.356	8.363	8.340	8.353	8.352	8.343	8.349	8.312
661	8.359	8.363	8.341	8.356	8.354	8.344	8.349	8.314
662	8.359	8.364	8.343	8.357	8.354	8.345	8.350	8.314
663	8.360	8.367	8.343	8.358	8.356	8.346	8.352	8.317
664	8.365	8.373	8.350	8.363	8.362	8.352	8.359	8.323
665	1.998	2.000	1.997	1.998	1.999	1.997	1.998	1.997
666	1.999	2.000	1.997	1.998	1.999	1.997	1.999	1.996
667	1.999	2.000	1.997	1.998	1.999	1.997	1.999	1.997
668	2.002	2.003	2.000	2.001	2.003	2.000	2.002	2.000
669	2.002	2.004	2.000	2.001	2.003	2.001	2.003	2.001
670	2.360	2.362	2.356	2.359	2.362	2.357	2.359	2.357
671	2.361	2.363	2.357	2.360	2.363	2.356	2.360	2.358
672	2.363	2.367	2.359	2.362	2.364	2.359	2.362	2.360
673	2.363	2.367	2.360	2.363	2.366	2.360	2.362	2.360
674	2.366	2.368	2.361	2.363	2.368	2.361	2.363	2.361
675	3.330	3.337	3.321	3.330	3.334	3.321	3.328	3.323
676	3.331	3.339	3.323	3.331	3.337	3.323	3.329	3.326
677	3.333	3.340	3.325	3.333	3.339	3.323	3.331	3.327
678	3.337	3.342	3.327	3.337	3.340	3.327	3.333	3.329
679	1.897	1.897	1.895	1.895	1.895	1.895	1.896	1.893
680	1.898	1.897	1.896	1.896	1.896	1.896	1.897	1.894
681	1.898	1.898	1.897	1.897	1.897	1.897	1.898	1.896
682	1.899	1.899	1.897	1.898	1.897	1.898	1.898	1.896
683	1.899	1.899	1.898	1.898	1.896	1.898	1.899	1.897
684	1.898	1.899	1.898	1.899	1.899	1.899	1.899	1.897
685	2.256	2.257	2.251	2.253	2.255	2.255	2.256	2.253
686	2.257	2.258	2.252	2.256	2.257	2.257	2.258	2.253
687	2.259	2.259	2.253	2.257	2.258	2.258	2.258	2.254
688	2.259	2.259	2.253	2.258	2.258	2.258	2.259	2.255

TABLE F7 (continued)

689	2.260	2.260	2.254	2.259	2.259	2.259	2.259	2.257
690	2.260	2.261	2.259	2.259	2.260	2.260	2.260	2.258
691	2.719	2.720	2.714	2.716	2.717	2.717	2.718	2.712
692	2.720	2.721	2.717	2.718	2.719	2.719	2.720	2.714
693	2.722	2.723	2.720	2.720	2.721	2.721	2.721	2.718
694	2.722	2.723	2.719	2.720	2.720	2.720	2.721	2.718
695	2.722	2.723	2.719	2.719	2.720	2.720	2.720	2.717
696	2.722	2.722	2.719	2.719	2.720	2.720	2.721	2.716
697	3.226	3.227	3.220	3.222	3.223	3.223	3.224	3.218
698	3.229	3.229	3.223	3.225	3.224	3.224	3.227	3.220
699	3.230	3.231	3.224	3.228	3.228	3.228	3.229	3.222
700	3.231	3.233	3.227	3.229	3.229	3.229	3.230	3.223
701	3.233	3.234	3.228	3.230	3.230	3.230	3.231	3.224
702	3.232	3.234	3.228	3.230	3.230	3.230	3.231	3.224
703	1.879	1.878	1.878	1.874	1.877	1.877	1.878	1.873
704	1.880	1.880	1.879	1.879	1.879	1.879	1.880	1.878
705	1.881	1.881	1.879	1.879	1.880	1.880	1.880	1.878
706	1.881	1.881	1.879	1.879	1.880	1.880	1.880	1.879
707	1.882	1.882	1.880	1.880	1.881	1.881	1.881	1.880
708	1.882	1.882	1.881	1.881	1.882	1.882	1.882	1.880
709	2.228	2.227	2.223	2.223	2.226	2.226	2.226	2.221
710	2.228	2.228	2.224	2.224	2.227	2.227	2.228	2.223
711	2.229	2.229	2.227	2.227	2.228	2.228	2.228	2.223
712	2.229	2.229	2.227	2.227	2.228	2.228	2.228	2.223
713	2.229	2.229	2.227	2.227	2.228	2.228	2.228	2.224
714	2.230	2.230	2.228	2.228	2.229	2.229	2.229	2.225
715	2.749	2.749	2.744	2.744	2.746	2.746	2.748	2.740
716	2.749	2.749	2.746	2.746	2.748	2.745	2.748	2.741
717	2.750	2.750	2.747	2.747	2.749	2.749	2.749	2.742
718	2.750	2.750	2.747	2.747	2.749	2.749	2.749	2.743
719	2.751	2.750	2.748	2.748	2.749	2.749	2.749	2.744
720	2.752	2.752	2.749	2.749	2.750	2.750	2.751	2.744
721	1.882	1.882	1.881	1.881	1.881	1.881	1.881	1.880
722	1.883	1.883	1.882	1.882	1.883	1.883	1.883	1.881
723	1.885	1.884	1.883	1.883	1.883	1.883	1.884	1.882
724	1.886	1.887	1.884	1.884	1.886	1.886	1.886	1.883
725	1.887	1.888	1.886	1.886	1.887	1.887	1.888	1.884
726	1.889	1.889	1.888	1.888	1.889	1.889	1.889	1.886
727	2.223	2.223	2.221	2.221	2.223	2.223	2.223	2.220
728	2.226	2.226	2.223	2.223	2.224	2.224	2.224	2.221
729	2.228	2.227	2.224	2.224	2.227	2.227	2.226	2.223
730	2.227	2.228	2.226	2.226	2.227	2.227	2.227	2.223
731	2.229	2.229	2.227	2.227	2.228	2.228	2.229	2.223
732	2.229	2.229	2.228	2.228	2.229	2.229	2.229	2.224
733	2.731	2.730	2.728	2.728	2.729	2.729	2.729	2.724
734	2.732	2.731	2.729	2.729	2.730	2.730	2.730	2.726
735	2.732	2.732	2.730	2.730	2.731	2.731	2.732	2.726
736	2.734	2.733	2.731	2.731	2.732	2.732	2.732	2.728
737	2.736	2.736	2.732	2.732	2.733	2.733	2.734	2.729
738	2.737	2.737	2.733	2.733	2.734	2.734	2.736	2.730

THE MEAN AND STD DEVIATION OF MILLIVOLT POSNS 19 TO27

K	XBAR	STD	TEMP	K	XBAR	STD	TEMP	K	XBAR	STD	TEMP
1	2.04914	0.00107	51.037	2	2.05271	0.00136	51.123	3	2.05471	0.00125	51.170
4	2.05671	0.00095	51.218	5	2.05829	0.00111	51.256	6	2.05871	0.00095	51.266
7	2.05886	0.00107	51.270	8	2.06029	0.00125	51.447	9	2.06100	0.00100	51.321
10	2.06066	0.00107	51.317	11	2.06157	0.00151	51.334	12	2.06229	0.00125	51.352
13	2.06243	0.00140	51.355	14	2.06329	0.00125	51.375	15	2.05829	0.00095	51.256
16	2.05971	0.00095	51.290	17	2.06014	0.00121	51.300	18	2.06057	0.00098	51.311
19	2.06057	0.00079	51.311	20	2.05957	0.00079	51.287	21	2.05986	0.00107	51.293
22	2.06014	0.00107	51.300	23	2.06229	0.00125	51.352	24	2.06343	0.00079	51.379
25	2.06314	0.00069	51.372	26	2.06271	0.00125	51.362	27	2.06229	0.00125	51.352
28	2.06186	0.00107	51.341	29	1.47914	0.00069	37.202	30	1.47700	0.00000	37.149
31	1.47400	0.00000	37.075	32	1.46700	0.00058	36.903	33	1.46386	0.00036	36.825
34	1.45100	0.00000	36.508	35	1.45200	0.00000	36.533	36	1.45286	0.00036	36.554
37	1.45286	0.00038	36.554	38	1.45514	0.00069	36.610	39	1.45586	0.00036	36.628
40	1.45700	0.00053	36.656	41	1.45757	0.00079	36.670	42	1.45786	0.00036	36.577
43	2.49629	0.00125	61.621	44	2.49600	0.00163	61.615	45	2.49629	0.00160	61.621
46	2.49657	0.00190	61.628	47	2.49629	0.00198	61.621	48	2.49614	0.00156	61.618
49	2.49557	0.00151	61.605	50	2.50071	0.00138	61.725	51	2.49971	0.00095	61.702
52	2.49986	0.00121	61.705	53	2.49900	0.00082	61.685	54	2.49743	0.00140	61.648
55	2.49686	0.00186	61.635	56	2.10614	0.00146	52.399	57	2.10129	0.00095	52.253
58	2.09657	0.00079	52.171	59	2.09457	0.00151	52.123	60	2.09186	0.00135	52.058
61	2.11586	0.00135	52.631	62	2.11057	0.00079	52.505	63	2.10500	0.00100	52.443
64	2.10643	0.00098	52.406	65	2.10557	0.00079	52.386	66	2.10071	0.00125	52.270
67	2.09971	0.00049	52.246	68	2.09971	0.00049	52.246	69	2.09257	0.00079	52.075
70	2.09100	0.00082	52.038	71	2.08971	0.00049	52.007	72	2.08871	0.00049	51.963
73	2.08857	0.00079	51.960	74	2.08486	0.00090	51.891	75	2.08029	0.00076	51.782
76	2.08071	0.00049	51.792	77	2.08071	0.00076	51.792	78	2.07471	0.00095	51.649
79	2.07814	0.00090	51.731	80	2.07814	0.00090	51.731	81	2.09071	0.00095	52.031
82	2.07886	0.00107	51.748	83	2.08571	0.00206	51.911	84	2.08171	0.00125	51.816
85	2.07743	0.00172	51.714	86	2.07657	0.00199	51.693	87	2.07714	0.00166	51.707
88	2.10014	0.00107	52.256	89	2.08986	0.00069	52.010	90	2.08371	0.00170	51.864
91	2.08186	0.00146	51.819	92	2.08100	0.00082	51.799	93	2.08686	0.00146	51.939
94	1.45971	0.00049	36.723	95	1.46486	0.00107	36.850	96	1.46443	0.00113	36.839
97	1.47029	0.00049	36.984	98	1.46986	0.00038	36.973	99	1.46886	0.00036	36.949
100	1.46800	0.00000	36.927	101	1.45986	0.00038	36.727	102	1.46771	0.00049	36.920
103	1.46786	0.00038	36.924	104	1.46771	0.00138	36.920	105	1.46743	0.00079	36.913
106	1.46357	0.00053	36.816	107	2.54614	0.00166	62.834	108	2.54043	0.00113	62.654
109	2.53271	0.00243	62.474	110	2.55071	0.00150	62.695	111	2.53971	0.00136	62.637
112	2.53329	0.00263	62.487	113	2.52957	0.00172	62.400	114	2.52357	0.00237	62.200
115	2.52014	0.00157	62.180	116	2.51643	0.00257	62.093	117	2.51357	0.00276	62.026
118	2.50671	0.00293	61.866	119	2.50200	0.00209	61.825	120	2.11771	0.00160	52.675
121	2.11186	0.00107	52.535	122	2.10743	0.00172	52.430	123	2.10157	0.00113	52.290
124	2.09700	0.00208	52.161	125	2.09186	0.00107	52.058	126	2.09014	0.00069	52.017
127	2.09071	0.00049	52.031	128	2.11400	0.00129	52.587	129	2.10971	0.00049	52.404
130	2.10686	0.00157	52.416	131	2.10143	0.00098	52.287	132	2.09629	0.00170	52.194
133	2.11100	0.00082	52.515	134	2.10871	0.00138	52.461	135	2.10529	0.00200	52.379
136	2.11100	0.00082	52.515	137	2.10657	0.00190	52.409	138	2.08957	0.00079	52.048
139	2.11371	0.00206	52.580	140	2.10714	0.00219	52.423	141	2.10029	0.00076	52.259
142	2.09729	0.00160	52.188	143	2.09014	0.00069	52.017	144	2.08786	0.00160	51.983
145	2.08686	0.00186	51.939	146	2.09000	0.00082	52.014	147	2.08866	0.00107	51.987
148	2.08229	0.00125	51.830	149	2.08214	0.00146	51.826	150	2.08057	0.00079	51.769
151	2.08000	0.00082	51.775	152	2.07971	0.00049	51.760	153	2.07871	0.00049	51.744
154	2.07571	0.00170	51.673	155	2.07643	0.00172	51.690	156	2.07571	0.00214	51.673
157	2.09014	0.00069	52.017	158	2.08714	0.00219	51.946	159	2.10175	0.00156	52.294
160	2.09788	0.00189	52.202	161	2.09286	0.00136	52.082	162	2.08975	0.00069	52.008
163	2.08738	0.00185	51.951	164	2.08257	0.00136	51.844	165	2.08075	0.00116	51.793
166	2.07487	0.00164	51.652	167	2.07312	0.00146	51.611	168	2.06975	0.00074	51.530
169	2.06903	0.00074	51.527	170	2.07250	0.00131	51.596	171	2.07225	0.00120	51.590
172	1.45075	0.00046	36.502	173	1.44900	0.00000	36.459	174	1.44475	0.00046	36.354
175	1.44350	0.00053	36.323	176	1.44175	0.00046	36.280	177	1.44068	0.00035	36.259
178	1.44000	0.00000	36.237	179	1.44000	0.00000	36.237	180	1.44068	0.00035	36.259
181	1.44137	0.00052	36.271	182	1.44138	0.00052	36.271	183	1.44188	0.00035	36.283
184	1.44137	0.00052	36.271	185	2.49675	0.00206	61.632	186	2.50113	0.00155	61.735
187	2.50050	0.00177	61.720	188	2.52175	0.00198	62.217	189	2.50713	0.00236	61.875
190	2.55050	0.00160	62.869	191	2.53825	0.00212	62.503	192	2.52975	0.00175	62.405
193	2.51113	0.00146	61.969	194	2.50837	0.00165	61.904	195	2.50313	0.00217	61.762
196	2.50162	0.00151	61.746	197	2.50275	0.00191	61.773	198	2.09913	0.00063	52.232
199	2.09338	0.00177	52.118	200	2.09100	0.00076	52.036	201	2.08925	0.00089	51.995
202	2.08763	0.00160	51.957	203	2.08850	0.00177	51.962	204	2.08503	0.00177	51.862
205	2.08238	0.00160	51.832	206	2.08175	0.00128	51.817	207	2.07962	0.00074	51.766
208	2.07950	0.00076	51.703	209	2.07900	0.00076	51.751	210	2.07363	0.00160	51.623
211	2.07750	0.00160	51.715	212	2.07686	0.00099	51.746	213	2.07813	0.00099	51.730

214	2.07850	0.00169	51.739	215	2.07638	0.00092	51.736	216	2.09963	0.00119	52.244
217	2.09563	0.00213	52.148	218	2.09138	0.00106	52.047	219	2.08900	0.00076	51.990
220	2.08613	0.00203	51.921	221	2.08438	0.00177	51.879	222	2.08163	0.00119	51.814
223	2.07663	0.00106	51.742	224	2.07125	0.00116	51.566	225	2.07163	0.00119	51.575
226	2.07013	0.00099	51.539	227	2.07175	0.00116	51.578	228	2.07213	0.00099	51.587
229	2.06738	0.00185	51.473	230	2.06863	0.00106	51.503	231	2.06875	0.00116	51.506
232	2.07238	0.00119	51.593	233	2.07363	0.00141	51.623	234	2.07487	0.00173	51.652
235	2.07438	0.00192	51.641	236	2.07575	0.00191	51.673	237	2.07200	0.00131	51.584
238	2.06925	0.00089	51.518	239	2.06750	0.00100	51.476	240	2.06575	0.00175	51.434
241	2.07163	0.00119	51.575	242	2.07125	0.00089	51.566	243	2.07163	0.00119	51.575
244	2.07150	0.00107	51.572	245	2.07200	0.00120	51.584	246	2.07188	0.00125	51.581
247	2.07200	0.00107	51.584	248	2.07275	0.00116	51.602	249	2.07275	0.00116	51.602
250	1.44388	0.00035	36.333	251	1.44288	0.00064	36.308	252	1.44275	0.00046	36.305
253	1.44188	0.00035	36.283	254	1.44175	0.00046	36.280	255	1.43968	0.00035	36.214
256	1.43988	0.00035	36.234	257	1.44000	0.00000	36.237	258	1.43988	0.00035	36.234
259	1.43875	0.00046	36.206	260	1.43888	0.00035	36.209	261	1.43888	0.00035	36.209
262	1.43900	0.00000	36.212	263	2.50700	0.00227	61.872	264	2.50812	0.00230	61.899
265	2.51125	0.00158	61.972	266	2.51187	0.00104	61.986	267	2.51203	0.00200	62.004
268	2.51313	0.00196	62.016	269	2.51300	0.00109	62.013	270	2.51550	0.00220	62.071
271	2.51612	0.00230	62.086	272	2.51650	0.00193	62.095	273	2.51663	0.00207	62.098
274	2.51313	0.00164	62.016	275	2.51425	0.00243	62.042	276	2.11663	0.00200	52.649
277	2.11250	0.00107	52.551	278	2.11200	0.00120	52.539	279	2.11025	0.00116	52.497
280	2.10962	0.00106	52.482	281	2.10825	0.00128	52.449	282	2.10575	0.00149	52.390
283	2.09988	0.00125	52.250	284	2.09987	0.00099	52.250	285	2.10125	0.00326	52.282
286	2.10175	0.00116	52.294	287	2.10275	0.00128	52.316	288	2.10300	0.00131	52.324
289	2.10187	0.00136	52.297	290	2.10363	0.00105	52.339	291	2.10225	0.00116	52.306
292	2.10187	0.00155	52.297	293	2.12037	0.00105	52.738	294	2.12163	0.00119	52.768
295	2.11363	0.00200	52.578	296	2.11563	0.00119	52.697	297	2.11075	0.00071	52.509
298	2.10050	0.00107	52.264	299	2.10038	0.00106	52.262	300	2.09912	0.00113	52.232
301	2.09688	0.00125	52.226	302	2.09100	0.00120	52.036	303	2.09113	0.00125	52.041
304	2.08850	0.00131	51.978	305	2.08875	0.00128	51.984	306	2.08825	0.00149	51.972
307	2.08000	0.00076	51.775	308	2.08050	0.00107	51.787	309	2.08075	0.00089	51.793
310	2.08137	0.00130	51.808	311	2.08325	0.00158	51.853	312	2.08287	0.00173	51.844
313	2.08275	0.00116	51.841	314	2.08250	0.00151	51.835	315	2.04625	0.00183	50.968
316	2.04725	0.00183	50.992	317	2.04825	0.00116	51.016	318	2.04875	0.00089	51.028
319	2.04963	0.00052	51.049	320	2.04988	0.00064	51.055	321	2.05000	0.00076	51.055
322	2.05163	0.00119	51.097	323	2.05200	0.00120	51.106	324	2.05275	0.00139	51.123
325	2.05237	0.00092	51.114	326	2.05725	0.00153	51.231	327	2.05863	0.00092	51.264
328	1.44613	0.00099	36.388	329	1.44638	0.00052	36.394	330	1.44575	0.00071	36.379
331	1.44613	0.00099	36.388	332	1.44537	0.00074	36.370	333	1.44537	0.00074	36.370
334	1.44563	0.00074	36.376	335	1.44388	0.00035	36.333	336	1.44425	0.00071	36.342
337	1.44500	0.00000	36.360	338	1.44375	0.00046	36.329	339	1.44500	0.00053	36.360
340	1.44500	0.00000	36.360	341	2.50437	0.00256	61.811	342	2.49675	0.00219	61.632
343	2.49138	0.00141	61.506	344	2.48288	0.00236	61.307	345	2.48013	0.00099	61.243
346	2.47863	0.00141	61.208	347	2.47713	0.00203	61.173	348	2.47063	0.00119	61.020
349	2.47075	0.00116	61.023	350	2.47088	0.00136	61.026	351	2.47100	0.00120	61.029
352	2.47212	0.00140	61.055	353	2.47375	0.00212	61.093	354	2.08013	0.00083	51.778
355	2.07775	0.00089	51.721	356	2.07583	0.00109	51.676	357	2.07175	0.00040	51.578
358	2.07075	0.00046	51.554	359	2.06925	0.00069	51.516	360	2.06875	0.00040	51.506
361	2.06302	0.00074	51.364	362	2.06662	0.00151	51.455	363	2.06500	0.00144	51.416
364	2.06063	0.00052	51.312	365	2.06150	0.00076	51.333	366	2.06200	0.00076	51.345
367	2.04225	0.00116	50.872	368	2.04450	0.00160	50.926	369	2.04603	0.00119	50.977
370	2.04737	0.00099	51.007	371	2.04850	0.00076	51.022	372	2.04988	0.00064	51.055
373	2.05050	0.00076	51.070	374	2.05000	0.00076	51.056	375	2.04900	0.00076	51.034
376	2.04350	0.00076	51.022	377	2.04935	0.00074	51.043	378	2.04587	0.00035	51.031
379	2.04988	0.00083	51.055	380	2.07163	0.00106	51.575	381	2.06975	0.00040	51.530
382	2.05663	0.00177	51.455	383	2.06262	0.00119	51.360	384	2.06100	0.00076	51.371
385	2.05337	0.00074	51.258	386	2.05750	0.00193	51.237	387	2.05713	0.00173	51.228
388	2.05463	0.00177	51.108	389	2.05312	0.00104	51.132	390	2.04850	0.00076	51.022
391	2.04862	0.00074	51.025	392	2.04825	0.00069	51.016	393	2.05412	0.00164	51.156
394	2.05788	0.00189	51.246	395	2.05888	0.00099	51.270	396	2.06038	0.00092	51.306
397	2.06038	0.00092	51.306	398	2.06262	0.00119	51.360	399	2.06425	0.00191	51.399
400	2.06650	0.00193	51.452	401	2.06787	0.00099	51.485	402	2.06838	0.00092	51.497
403	2.06913	0.00083	51.515	404	2.06913	0.00063	51.515	405	2.06813	0.00125	51.491
406	2.47888	0.00099	61.214	407	2.48100	0.00177	61.263	408	2.48263	0.00177	61.301
409	2.48450	0.00220	61.345	410	2.48858	0.00247	61.401	411	2.48725	0.00243	61.410
412	2.48700	0.00251	61.404	413	2.48713	0.00242	61.407	414	2.48912	0.00130	61.454
415	2.48963	0.00141	61.465	416	2.49038	0.00119	61.483	417	2.49138	0.00160	61.506
418	2.49175	0.00128	61.515	419	1.45787	0.00063	36.676	420	1.45462	0.00074	36.593
421	1.45287	0.00035	36.555	422	1.45087	0.00035	36.505	423	1.45012	0.00035	36.487
424	1.44837	0.00052	36.444	425	1.44837	0.00052	36.444	426	1.44763	0.00035	36.431
427	1.44525	0.00071	36.366	428	1.44188	0.00035	36.283	429	1.44287	0.00035	36.305
430	1.44238	0.00074	36.296	431	1.44213	0.00035	36.289	432	2.06225	0.00089	51.351
433	2.06225	0.00089	51.351	434	2.06350	0.00131	51.381	435	2.06212	0.00083	51.348
436	2.06188	0.00099	51.342	437	2.06075	0.00046	51.315	438	2.05675	0.00183	51.219
439	2.05712	0.00164	51.228	440	2.05675	0.00191	51.219	441	2.05700	0.00193	51.225
442	2.05737	0.00160	51.234	443	2.05787	0.00099	51.246	444	2.05825	0.00116	51.255

445	2.03000	0.00053	50.579	446	2.03225	0.00116	50.633	447	2.03663	0.00177	50.738
448	2.03963	0.00074	50.609	449	2.04057	0.00099	50.639	450	2.04450	0.00160	50.926
451	2.04650	0.00160	50.974	452	2.04775	0.00104	51.004	453	2.04900	0.00076	51.034
454	2.05037	0.00092	51.007	455	2.05037	0.00092	51.067	456	2.05037	0.00092	51.067
457	2.05000	0.00076	51.058	458	2.51900	0.00273	62.153	459	2.51913	0.00275	62.156
460	2.51675	0.00260	62.147	461	2.51938	0.00250	62.162	462	2.51963	0.00267	62.168
463	2.52188	0.00270	62.220	464	2.52263	0.00256	62.236	465	2.52288	0.00295	62.244
466	2.52338	0.00307	62.255	467	2.52425	0.00315	62.276	468	2.52313	0.00314	62.250
469	2.52213	0.00259	62.226	470	2.52025	0.00243	62.182	471	2.53275	0.00301	62.475
472	2.53175	0.00219	62.451	473	2.52538	0.00325	62.372	474	2.52838	0.00280	62.372
475	2.52750	0.00312	62.352	476	2.52650	0.00325	62.329	477	2.52600	0.00330	62.317
478	2.52550	0.00316	62.305	479	2.52437	0.00307	62.279	480	2.51913	0.00230	62.156
481	2.51913	0.00275	62.156	482	2.51900	0.00273	62.153	483	2.51950	0.00262	62.165
484	2.42538	0.00302	59.958	485	2.42525	0.00292	59.955	486	2.42575	0.00300	59.967
487	2.42463	0.00292	59.940	488	2.42425	0.00276	59.932	489	2.42500	0.00262	59.949
490	2.42462	0.00233	59.940	491	2.42375	0.00271	59.920	492	2.42375	0.00260	59.920
493	2.42225	0.00324	59.855	494	2.42313	0.00323	59.905	495	2.42325	0.00315	59.908
496	2.42238	0.00325	59.887	497	1.87025	0.00071	46.738	498	1.87025	0.00071	46.738
499	1.87025	0.00071	46.738	500	1.87000	0.00076	46.732	501	1.87000	0.00076	46.732
502	1.87000	0.00076	46.732	503	1.86788	0.00099	46.680	504	1.86825	0.00089	46.689
505	1.86850	0.00093	46.695	506	1.86875	0.00116	46.701	507	1.86888	0.00099	46.704
508	1.86850	0.00107	46.695	509	1.86888	0.00099	46.704	510	2.43162	0.00200	60.105
511	2.43263	0.00226	60.126	512	2.43338	0.00268	60.146	513	2.43375	0.00249	60.155
514	2.43375	0.00219	60.155	515	2.43400	0.00259	60.161	516	2.43425	0.00260	60.166
517	2.43400	0.00256	60.161	518	2.43400	0.00256	60.161	519	2.43225	0.01313	60.120
520	2.43350	0.00957	60.149	521	2.43388	0.00979	60.158	522	2.43400	0.00986	60.161
523	2.60025	0.00262	64.050	524	2.47588	0.35351	61.143	525	2.60013	0.00275	64.047
526	2.59875	0.00282	64.015	527	2.59875	0.00292	64.015	528	2.59875	0.00292	64.015
529	2.59850	0.00288	64.010	530	2.59900	0.00262	64.021	531	2.59912	0.00275	64.024
532	2.59938	0.00250	64.030	533	2.59925	0.00243	64.027	534	2.59925	0.00249	64.027
535	2.59900	0.00273	64.021	536	2.15388	0.00125	53.537	537	2.15375	0.00139	53.534
538	2.15312	0.00164	53.519	539	2.15300	0.00107	53.516	540	2.15275	0.00104	53.510
541	2.15375	0.00175	53.534	542	2.15488	0.00155	53.561	543	2.15575	0.00120	53.581
544	4.90775	0.01659	115.213	545	4.91488	0.01597	115.364	546	4.91938	0.01595	115.459
547	4.92125	0.01724	115.498	548	4.91925	0.01675	115.456	549	1.90950	0.00076	47.694
550	1.91013	0.00083	47.699	551	1.91125	0.00089	47.726	552	1.91388	0.00164	47.790
553	1.91475	0.00158	47.811	554	1.91588	0.00173	47.835	555	1.91663	0.00177	47.856
556	2.26988	0.00146	56.291	557	2.27063	0.00130	56.306	558	2.27125	0.00150	56.323
559	2.27213	0.00146	56.344	560	2.27275	0.00175	56.359	561	2.27275	0.00175	56.359
562	2.27300	0.00160	56.364	563	2.26913	0.00169	56.273	564	2.26988	0.00140	56.291
565	2.27050	0.00141	56.305	566	2.27163	0.00200	56.332	567	2.27213	0.00189	56.344
568	2.69250	0.00245	66.196	569	2.69750	0.00227	66.312	570	2.70013	0.00169	66.373
571	2.70213	0.00217	66.419	572	2.70525	0.00267	66.491	573	2.70900	0.00239	66.578
574	2.71138	0.00245	66.633	575	2.71100	0.00185	66.625	576	3.15325	0.00337	76.777
577	3.15450	0.00342	76.805	578	3.15575	0.00333	76.833	579	3.15600	0.00316	76.839
580	3.15750	0.00288	76.873	581	3.15550	0.00293	76.890	582	3.15925	0.00292	76.913
583	3.15988	0.00285	76.927	584	2.93963	0.00329	71.890	585	2.94100	0.00334	71.930
586	2.93725	0.00377	71.844	587	2.93613	0.00372	71.810	588	2.93400	0.00355	71.769
589	4.35763	0.00709	103.456	590	4.35800	0.00607	103.464	591	4.35713	0.00656	103.445
592	4.35600	0.00663	103.421	593	4.35525	0.00701	103.404	594	4.35813	0.00690	103.467
595	6.50438	0.01263	149.194	596	6.50338	0.01322	149.174	597	6.50200	0.01295	149.147
598	6.50263	0.01318	149.159	599	3.71963	0.00501	89.491	600	3.72088	0.00480	89.519
601	3.72138	0.00518	89.530	602	3.72213	0.00500	89.547	603	3.72500	0.00465	89.622
604	3.72775	0.00465	89.672	605	3.16950	0.00307	77.140	606	3.17058	0.00344	77.177
607	3.17188	0.00344	77.200	608	3.17200	0.00298	77.203	609	3.17263	0.00325	77.217
610	3.17300	0.00342	77.225	611	4.02550	0.00510	96.232	612	4.02600	0.00526	96.267
613	4.02938	0.00529	96.317	614	4.03013	0.00506	96.333	615	4.03100	0.00535	96.352
616	4.03363	0.00524	96.410	617	4.79213	0.00722	112.763	618	4.79350	0.00652	112.792
619	4.79550	0.00661	112.834	620	4.79750	0.00608	112.877	621	4.80000	0.00654	112.930
622	4.80225	0.00676	112.978	623	7.26075	0.01279	162.903	624	7.27263	0.01337	163.134
625	7.27638	0.01393	163.207	626	7.28038	0.01359	163.295	627	7.26375	0.01351	163.051
628	7.29013	0.01366	163.475	629	3.57813	0.00419	86.344	630	3.57725	0.00396	86.309
631	3.58075	0.00388	86.402	632	3.58088	0.00298	86.405	633	3.58213	0.00391	86.433
634	3.58213	0.00348	86.433	635	3.50638	0.00283	84.785	636	3.51025	0.00333	84.827
637	3.51088	0.00323	84.841	638	3.51200	0.00321	84.866	639	3.51238	0.00302	84.875
640	3.51388	0.00344	84.908	641	3.94350	0.00469	94.435	642	3.94563	0.00425	94.400
643	3.94575	0.00406	94.403	644	3.94663	0.00437	94.508	645	3.94688	0.00400	94.497
646	3.94725	0.00427	94.516	647	4.83450	0.00502	109.405	648	4.83525	0.00597	109.421
649	4.83500	0.00578	109.415	650	4.83513	0.00591	109.415	651	4.83600	0.00621	109.437
652	4.83663	0.00614	109.450	653	5.45525	0.00723	126.670	654	5.45688	0.00779	126.704
655	5.45738	0.00769	126.714	656	5.45750	0.00746	126.717	657	5.45825	0.00763	126.732
658	5.45838	0.00748	126.735	659	8.34413	0.01506	183.629	660	8.34600	0.01551	183.604
661	8.34750	0.01543	183.693	662	8.34825	0.01553	183.707	663	8.35013	0.01520	183.742
664	8.35588	0.01514	183.850	665	1.99500	0.00107	49.812	666	1.99813	0.00136	49.815
667	1.99825	0.00116	49.818	668	2.00138	0.00130	49.893	669	2.00188	0.00130	49.905
670	2.35900	0.00227	58.396	671	2.36000	0.00227	58.419	672	2.36200	0.00273	58.407
673	2.36262	0.00272	58.401	674	2.36388	0.00304	58.511	675	3.32800	0.00595	60.733

TABLE F8 (continued)

676	3.32988	0.00594	80.775	677	3.33138	0.00619	80.809	678	3.33400	0.00580	80.868
679	1.89538	0.00130	47.344	680	1.89625	0.00116	47.365	681	1.89725	0.00071	47.369
682	1.89775	0.00104	47.401	683	1.89825	0.00071	47.413	684	1.89850	0.00076	47.419
685	2.25450	0.00200	55.926	686	2.25600	0.00227	55.962	687	2.25700	0.00227	55.986
688	2.25738	0.00220	55.995	689	2.25537	0.00200	56.016	690	2.25963	0.00092	56.048
691	2.71663	0.00262	66.755	692	2.71850	0.00220	66.799	693	2.72075	0.00149	66.851
694	2.72038	0.00160	66.642	695	2.72000	0.00165	66.833	696	2.71988	0.00196	66.831
697	3.22258	0.00295	78.357	698	3.22513	0.00309	78.408	699	3.22750	0.00302	78.461
700	3.22388	0.00295	78.492	701	3.23000	0.00307	78.516	702	3.22988	0.00295	78.515
703	1.87675	0.00212	46.895	704	1.87925	0.00071	46.955	705	1.87975	0.00104	46.967
706	1.87988	0.00083	46.970	707	1.88088	0.00063	46.994	708	1.88150	0.00076	47.009
709	2.22500	0.00239	55.227	710	2.22612	0.00210	55.254	711	2.22738	0.00192	55.263
712	2.22738	0.00192	55.283	713	2.22750	0.00160	55.266	714	2.22850	0.00160	55.310
715	2.74575	0.00305	67.430	716	2.74688	0.00234	67.456	717	2.74757	0.00264	67.479
718	2.74800	0.00233	67.462	719	2.74650	0.00207	67.494	720	2.74903	0.00256	67.520
721	1.88113	0.00064	47.000	722	1.88250	0.00076	47.033	723	1.88338	0.00092	47.054
724	1.88525	0.00139	47.100	725	1.88663	0.00130	47.133	726	1.88837	0.00106	47.175
727	2.22213	0.00125	55.159	728	2.22388	0.00164	55.200	729	2.22575	0.00183	55.245
730	2.22637	0.00151	55.200	731	2.22750	0.00200	55.286	732	2.22813	0.00173	55.301
733	2.72850	0.00207	67.030	734	2.72963	0.00177	67.056	735	2.73050	0.00200	67.077
736	2.73163	0.00177	67.103	737	2.73313	0.00230	67.135	738	2.73425	0.00238	67.164

TABLE F9

Raw Experimental Data

Thermocouple Wires Numbers 28 to 32

MILLIVOLTS READ IN FOR POSITIONS 28 TO 32 ARE

1	1.974	1.977	1.976	1.976	1.976
2	1.978	1.979	1.979	1.978	1.979
3	1.979	1.981	1.981	1.981	1.981
4	1.981	1.983	1.983	1.983	1.983
5	1.982	1.983	1.984	1.984	1.984
6	1.984	1.984	1.984	1.984	1.984
7	1.983	1.985	1.984	1.984	1.984
8	1.990	1.992	1.992	1.991	1.992
9	1.985	1.987	1.986	1.986	1.986
10	1.985	1.987	1.986	1.985	1.985
11	1.985	1.988	1.986	1.986	1.986
12	1.986	1.988	1.988	1.988	1.988
13	1.987	1.988	1.987	1.987	1.987
14	1.987	1.988	1.988	1.988	1.988
15	1.981	1.983	1.983	1.983	1.983
16	1.981	1.984	1.983	1.983	1.983
17	1.983	1.984	1.984	1.984	1.984
18	1.983	1.985	1.984	1.984	1.984
19	1.984	1.985	1.984	1.984	1.984
20	1.983	1.984	1.984	1.984	1.984
21	1.983	1.984	1.984	1.984	1.984
22	1.983	1.984	1.984	1.984	1.984
23	1.985	1.987	1.987	1.987	1.987
24	1.986	1.987	1.986	1.986	1.986
25	1.986	1.988	1.986	1.986	1.986
26	1.984	1.987	1.986	1.986	1.986
27	1.984	1.987	1.985	1.985	1.985
28	1.984	1.985	1.986	1.986	1.986
29	1.462	1.462	1.462	1.462	1.462
30	1.458	1.458	1.458	1.458	1.458
31	1.456	1.456	1.455	1.455	1.455
32	1.448	1.448	1.448	1.448	1.448
33	1.446	1.446	1.446	1.446	1.446
34	1.434	1.434	1.434	1.434	1.434
35	1.436	1.436	1.436	1.436	1.436
36	1.438	1.438	1.438	1.438	1.438
37	1.437	1.437	1.437	1.437	1.437
38	1.438	1.439	1.439	1.439	1.439
39	1.439	1.440	1.440	1.440	1.440
40	1.440	1.440	1.440	1.440	1.440
41	1.441	1.441	1.441	1.441	1.441
42	1.440	1.441	1.441	1.441	1.441
43	2.368	2.372	2.370	2.370	2.370
44	2.367	2.360	2.369	2.369	2.369
45	2.368	2.371	2.369	2.369	2.369
46	2.368	2.371	2.370	2.370	2.370
47	2.368	2.371	2.370	2.371	2.370
48	2.368	2.371	2.369	2.369	2.369
49	2.368	2.370	2.369	2.369	2.369
50	2.373	2.376	2.374	2.375	2.374
51	2.373	2.376	2.374	2.374	2.374
52	2.373	2.376	2.374	2.374	2.374
53	2.371	2.374	2.373	2.373	2.373
54	2.369	2.372	2.370	2.371	2.371
55	2.369	2.371	2.370	2.371	2.371
56	2.030	2.033	2.032	2.032	2.032
57	2.027	2.029	2.028	2.028	2.029
58	2.023	2.024	2.024	2.024	2.024
59	2.020	2.023	2.021	2.021	2.021
60	2.019	2.020	2.020	2.019	2.019
61	2.039	2.041	2.040	2.040	2.040
62	2.035	2.037	2.036	2.037	2.037
63	2.031	2.034	2.034	2.034	2.034
64	2.030	2.033	2.032	2.032	2.032
65	2.030	2.031	2.031	2.031	2.031
66	2.026	2.028	2.028	2.028	2.028
67	2.025	2.028	2.027	2.027	2.027
68	2.025	2.027	2.027	2.026	2.026
69	2.020	2.022	2.021	2.021	2.021
70	2.019	2.020	2.020	2.020	2.020
71	2.017	2.020	2.020	2.020	2.020
72	2.017	2.019	2.018	2.018	2.018

TABLE F9 (continued)

73	2.017	2.019	2.018	2.018	2.018
74	2.013	2.016	2.014	2.014	2.015
75	2.009	2.011	2.011	2.011	2.011
76	2.010	2.011	2.011	2.011	2.011
77	2.009	2.010	2.010	2.010	2.010
78	2.003	2.007	2.006	2.006	2.006
79	2.006	2.009	2.008	2.008	2.008
80	2.007	2.009	2.009	2.009	2.009
81	1.967	1.969	1.968	1.968	1.968
82	1.955	1.959	1.958	1.958	1.958
83	1.962	1.964	1.964	1.964	1.964
84	1.960	1.961	1.961	1.960	1.961
85	1.954	1.958	1.957	1.957	1.957
86	1.953	1.953	1.955	1.955	1.955
87	1.954	1.957	1.956	1.955	1.956
88	1.974	1.978	1.975	1.975	1.976
89	1.967	1.969	1.969	1.969	1.969
90	1.961	1.963	1.962	1.962	1.962
91	1.960	1.961	1.960	1.960	1.960
92	1.959	1.960	1.960	1.960	1.960
93	1.963	1.965	1.963	1.964	1.965
94	1.431	1.431	1.431	1.431	1.431
95	1.437	1.437	1.437	1.437	1.437
96	1.436	1.436	1.436	1.436	1.436
97	1.441	1.441	1.441	1.441	1.441
98	1.441	1.441	1.441	1.441	1.441
99	1.440	1.440	1.440	1.440	1.440
100	1.439	1.439	1.439	1.439	1.439
101	1.431	1.431	1.431	1.431	1.431
102	1.439	1.439	1.439	1.439	1.439
103	1.439	1.439	1.439	1.439	1.439
104	1.439	1.439	1.439	1.439	1.439
105	1.439	1.439	1.439	1.439	1.439
106	1.437	1.438	1.438	1.437	1.437
107	2.349	2.352	2.351	2.351	2.351
108	2.344	2.349	2.347	2.347	2.348
109	2.338	2.340	2.339	2.339	2.339
110	2.351	2.354	2.354	2.353	2.353
111	2.343	2.348	2.346	2.347	2.347
112	2.339	2.341	2.340	2.340	2.341
113	2.333	2.339	2.337	2.337	2.337
114	2.329	2.331	2.330	2.330	2.330
115	2.326	2.329	2.329	2.329	2.329
116	2.321	2.327	2.324	2.324	2.325
117	2.320	2.322	2.321	2.321	2.321
118	2.311	2.316	2.314	2.314	2.314
119	2.310	2.313	2.312	2.312	2.312
120	1.978	1.979	1.979	1.979	1.979
121	1.974	1.977	1.976	1.976	1.976
122	1.969	1.970	1.970	1.970	1.970
123	1.965	1.968	1.967	1.967	1.966
124	1.959	1.960	1.960	1.960	1.960
125	1.958	1.959	1.959	1.959	1.959
126	1.954	1.957	1.956	1.956	1.956
127	1.956	1.959	1.958	1.958	1.958
128	1.974	1.977	1.975	1.976	1.976
129	1.971	1.972	1.971	1.971	1.971
130	1.969	1.970	1.970	1.970	1.970
131	1.964	1.968	1.965	1.966	1.968
132	1.959	1.961	1.960	1.960	1.960
133	1.981	1.984	1.983	1.983	1.983
134	1.980	1.981	1.980	1.980	1.981
135	1.978	1.979	1.979	1.979	1.979
136	1.982	1.984	1.983	1.983	1.984
137	1.979	1.980	1.980	1.979	1.979
138	1.961	1.963	1.962	1.962	1.962
139	1.985	1.988	1.987	1.986	1.988
140	1.980	1.981	1.981	1.981	1.981
141	1.975	1.977	1.976	1.975	1.976
142	1.970	1.972	1.971	1.971	1.971
143	1.965	1.968	1.967	1.967	1.967
144	1.961	1.963	1.962	1.962	1.962
145	1.960	1.962	1.961	1.961	1.961
146	1.961	1.962	1.962	1.962	1.962
147	1.960	1.961	1.960	1.960	1.960
148	1.956	1.958	1.957	1.957	1.957
149	1.956	1.958	1.957	1.957	1.957

TABLE F9 (continued)

150	1.954	1.956	1.956	1.956	1.956
151	1.952	1.954	1.953	1.953	1.953
152	1.951	1.953	1.951	1.951	1.951
153	1.950	1.952	1.951	1.951	1.951
154	1.949	1.950	1.949	1.949	1.950
155	1.949	1.950	1.950	1.950	1.950
156	1.949	1.950	1.949	1.949	1.949
157	1.962	1.963	1.962	1.962	1.962
158	1.960	1.960	1.960	1.960	1.960
159	1.931	1.934	1.933	1.933	1.933
160	1.929	1.930	1.929	1.929	1.929
161	1.924	1.929	1.928	1.927	1.927
162	1.920	1.922	1.921	1.921	1.921
163	1.919	1.921	1.920	1.920	1.921
164	1.917	1.919	1.918	1.918	1.919
165	1.914	1.918	1.917	1.916	1.916
166	1.909	1.910	1.908	1.909	1.909
167	1.907	1.909	1.909	1.909	1.909
168	1.902	1.904	1.903	1.903	1.903
169	1.902	1.905	1.903	1.903	1.904
170	1.906	1.909	1.908	1.908	1.908
171	1.906	1.909	1.908	1.909	1.909
172	1.414	1.414	1.414	1.414	1.414
173	1.411	1.411	1.411	1.411	1.411
174	1.409	1.409	1.409	1.409	1.409
175	1.408	1.408	1.408	1.408	1.408
176	1.405	1.405	1.405	1.405	1.405
177	1.404	1.405	1.405	1.404	1.404
178	1.403	1.403	1.403	1.403	1.403
179	1.404	1.404	1.404	1.404	1.404
180	1.404	1.405	1.405	1.405	1.404
181	1.407	1.407	1.407	1.407	1.407
182	1.405	1.405	1.405	1.405	1.405
183	1.406	1.406	1.406	1.406	1.406
184	1.405	1.405	1.405	1.405	1.405
185	2.230	2.234	2.232	2.231	2.232
186	2.238	2.240	2.239	2.238	2.239
187	2.235	2.239	2.238	2.238	2.238
188	2.253	2.259	2.258	2.258	2.257
189	2.240	2.244	2.242	2.241	2.242
190	2.277	2.280	2.279	2.279	2.279
191	2.267	2.270	2.269	2.269	2.269
192	2.259	2.262	2.260	2.259	2.260
193	2.241	2.248	2.245	2.244	2.245
194	2.240	2.244	2.242	2.241	2.242
195	2.234	2.239	2.238	2.237	2.238
196	2.234	2.239	2.238	2.238	2.238
197	2.237	2.240	2.239	2.239	2.239
198	1.930	1.932	1.932	1.931	1.932
199	1.928	1.929	1.929	1.929	1.929
200	1.925	1.929	1.928	1.928	1.928
201	1.923	1.926	1.925	1.924	1.924
202	1.921	1.923	1.922	1.922	1.922
203	1.919	1.921	1.920	1.920	1.920
204	1.919	1.920	1.920	1.920	1.920
205	1.918	1.920	1.920	1.919	1.919
206	1.918	1.920	1.919	1.919	1.919
207	1.914	1.918	1.917	1.917	1.917
208	1.913	1.918	1.917	1.917	1.917
209	1.913	1.917	1.916	1.915	1.915
210	1.909	1.910	1.910	1.910	1.910
211	1.907	1.909	1.908	1.908	1.909
212	1.908	1.910	1.909	1.909	1.909
213	1.907	1.910	1.909	1.908	1.909
214	1.908	1.910	1.909	1.909	1.909
215	1.907	1.910	1.909	1.908	1.909
216	1.927	1.929	1.929	1.928	1.929
217	1.922	1.927	1.924	1.924	1.924
218	1.921	1.922	1.922	1.921	1.921
219	1.918	1.920	1.920	1.919	1.919
220	1.913	1.918	1.918	1.917	1.917
221	1.913	1.918	1.915	1.915	1.915
222	1.911	1.914	1.913	1.911	1.912
223	1.908	1.910	1.909	1.909	1.909
224	1.903	1.907	1.905	1.904	1.906
225	1.903	1.907	1.906	1.905	1.905
226	1.902	1.904	1.903	1.902	1.903

TABLE F9 (continued)

227	1.903	1.906	1.906	1.905	1.907
228	1.904	1.908	1.907	1.905	1.907
229	1.899	1.900	1.900	1.899	1.900
230	1.900	1.902	1.901	1.900	1.901
231	1.900	1.902	1.901	1.906	1.901
232	1.905	1.909	1.908	1.907	1.907
233	1.907	1.909	1.908	1.906	1.909
234	1.907	1.910	1.909	1.909	1.909
235	1.907	1.909	1.909	1.909	1.909
236	1.908	1.910	1.909	1.909	1.909
237	1.899	1.901	1.900	1.900	1.900
238	1.896	1.899	1.898	1.898	1.898
239	1.892	1.897	1.895	1.895	1.895
240	1.892	1.894	1.894	1.893	1.894
241	1.899	1.900	1.900	1.899	1.900
242	1.899	1.901	1.901	1.900	1.900
243	1.899	1.901	1.901	1.900	1.900
244	1.899	1.902	1.900	1.900	1.900
245	1.899	1.902	1.901	1.900	1.902
246	1.899	1.902	1.901	1.900	1.900
247	1.900	1.902	1.901	1.901	1.901
248	1.900	1.902	1.902	1.901	1.902
249	1.900	1.902	1.902	1.901	1.902
250	1.405	1.406	1.405	1.405	1.405
251	1.405	1.406	1.406	1.406	1.406
252	1.404	1.404	1.404	1.404	1.404
253	1.403	1.404	1.404	1.404	1.404
254	1.403	1.404	1.403	1.403	1.403
255	1.402	1.402	1.402	1.402	1.402
256	1.402	1.402	1.402	1.402	1.402
257	1.402	1.402	1.402	1.402	1.402
258	1.401	1.401	1.401	1.401	1.401
259	1.400	1.400	1.400	1.400	1.400
260	1.400	1.400	1.400	1.400	1.400
261	1.400	1.401	1.400	1.401	1.401
262	1.401	1.401	1.401	1.401	1.401
263	2.228	2.232	2.230	2.230	2.231
264	2.229	2.233	2.232	2.231	2.232
265	2.231	2.238	2.235	2.233	2.236
266	2.232	2.238	2.237	2.236	2.238
267	2.233	2.239	2.238	2.237	2.238
268	2.234	2.239	2.238	2.237	2.239
269	2.233	2.239	2.238	2.237	2.238
270	2.237	2.240	2.240	2.239	2.240
271	2.237	2.240	2.240	2.239	2.240
272	2.237	2.241	2.239	2.240	2.240
273	2.237	2.240	2.239	2.239	2.240
274	2.233	2.239	2.238	2.237	2.239
275	2.234	2.239	2.238	2.238	2.239
276	1.939	1.941	1.940	1.940	1.940
277	1.939	1.940	1.939	1.939	1.940
278	1.939	1.940	1.939	1.939	1.939
279	1.936	1.939	1.937	1.937	1.938
280	1.935	1.938	1.936	1.937	1.937
281	1.932	1.936	1.933	1.934	1.934
282	1.931	1.933	1.931	1.932	1.932
283	1.927	1.929	1.928	1.929	1.929
284	1.928	1.929	1.928	1.928	1.928
285	1.928	1.929	1.928	1.929	1.929
286	1.929	1.931	1.930	1.930	1.930
287	1.930	1.932	1.931	1.931	1.931
288	1.930	1.932	1.930	1.930	1.931
289	1.942	1.944	1.943	1.943	1.943
290	1.943	1.947	1.944	1.944	1.944
291	1.943	1.945	1.943	1.943	1.944
292	1.942	1.945	1.943	1.943	1.943
293	1.963	1.967	1.965	1.964	1.964
294	1.961	1.963	1.962	1.962	1.962
295	1.958	1.960	1.959	1.959	1.959
296	1.952	1.957	1.955	1.955	1.955
297	1.951	1.953	1.951	1.951	1.951
298	1.942	1.943	1.943	1.942	1.942
299	1.942	1.944	1.943	1.943	1.943
300	1.940	1.942	1.941	1.942	1.942
301	1.940	1.942	1.941	1.941	1.941
302	1.935	1.938	1.937	1.937	1.937
303	1.935	1.938	1.937	1.937	1.937

TABLE F9 (continued)

304	1.931	1.932	1.931	1.931	1.932
305	1.931	1.933	1.932	1.932	1.932
306	1.931	1.933	1.932	1.932	1.932
307	1.924	1.928	1.926	1.926	1.926
308	1.925	1.928	1.927	1.927	1.927
309	1.926	1.928	1.928	1.928	1.928
310	1.928	1.929	1.929	1.929	1.929
311	1.929	1.930	1.929	1.929	1.929
312	1.929	1.930	1.929	1.929	1.929
313	1.929	1.930	1.929	1.929	1.929
314	1.928	1.929	1.929	1.929	1.929
315	1.952	1.954	1.954	1.953	1.953
316	1.953	1.958	1.957	1.957	1.956
317	1.956	1.959	1.958	1.957	1.958
318	1.956	1.959	1.959	1.958	1.959
319	1.957	1.959	1.959	1.958	1.959
320	1.958	1.960	1.960	1.959	1.960
321	1.958	1.960	1.960	1.959	1.960
322	1.959	1.961	1.961	1.960	1.961
323	1.959	1.962	1.962	1.960	1.961
324	1.960	1.962	1.961	1.961	1.961
325	1.960	1.962	1.961	1.961	1.961
326	1.962	1.965	1.964	1.964	1.966
327	1.963	1.967	1.967	1.964	1.966
328	1.424	1.424	1.424	1.424	1.424
329	1.424	1.424	1.425	1.425	1.425
330	1.424	1.424	1.424	1.424	1.424
331	1.424	1.424	1.424	1.424	1.424
332	1.424	1.424	1.424	1.424	1.424
333	1.424	1.424	1.424	1.424	1.424
334	1.423	1.424	1.424	1.424	1.424
335	1.422	1.423	1.423	1.423	1.423
336	1.423	1.423	1.423	1.423	1.423
337	1.423	1.424	1.424	1.424	1.424
338	1.423	1.423	1.423	1.423	1.423
339	1.424	1.424	1.424	1.424	1.424
340	1.424	1.424	1.424	1.424	1.424
341	2.352	2.357	2.355	2.354	2.356
342	2.344	2.349	2.349	2.347	2.349
343	2.340	2.344	2.342	2.342	2.343
344	2.332	2.338	2.337	2.335	2.337
345	2.330	2.334	2.333	2.331	2.333
346	2.329	2.332	2.331	2.330	2.331
347	2.328	2.330	2.330	2.329	2.330
348	2.320	2.324	2.323	2.322	2.324
349	2.321	2.325	2.324	2.323	2.324
350	2.321	2.326	2.325	2.323	2.324
351	2.321	2.327	2.324	2.323	2.325
352	2.322	2.328	2.328	2.325	2.327
353	2.323	2.329	2.328	2.327	2.329
354	1.989	1.991	1.990	1.990	1.990
355	1.985	1.989	1.989	1.987	1.989
356	1.983	1.987	1.987	1.984	1.987
357	1.981	1.983	1.983	1.981	1.982
358	1.980	1.982	1.981	1.980	1.981
359	1.978	1.980	1.980	1.979	1.980
360	1.972	1.976	1.975	1.974	1.975
361	1.974	1.978	1.978	1.976	1.978
362	1.973	1.977	1.977	1.976	1.976
363	1.970	1.972	1.971	1.971	1.971
364	1.971	1.973	1.972	1.972	1.973
365	1.971	1.974	1.973	1.972	1.973
366	1.953	1.957	1.956	1.954	1.956
367	1.956	1.959	1.959	1.959	1.959
368	1.958	1.960	1.959	1.959	1.959
369	1.959	1.960	1.960	1.960	1.960
370	1.959	1.961	1.961	1.960	1.960
371	1.961	1.962	1.962	1.962	1.962
372	1.961	1.963	1.962	1.962	1.962
373	1.961	1.963	1.963	1.962	1.962
374	1.960	1.962	1.961	1.961	1.961
375	1.960	1.962	1.961	1.961	1.961
376	1.958	1.961	1.960	1.961	1.961
377	1.960	1.961	1.961	1.961	1.961
378	1.960	1.961	1.961	1.961	1.961
379	1.961	1.962	1.961	1.961	1.961
380	1.981	1.983	1.983	1.983	1.983

TABLE F9 (continued)

381	1.980	1.981	1.980	1.980	1.980
382	1.978	1.979	1.978	1.979	1.979
383	1.973	1.977	1.977	1.975	1.975
384	1.971	1.973	1.972	1.972	1.971
385	1.969	1.970	1.969	1.969	1.969
386	1.968	1.970	1.969	1.969	1.969
387	1.967	1.969	1.969	1.968	1.968
388	1.966	1.969	1.968	1.968	1.968
389	1.964	1.968	1.967	1.967	1.967
390	1.960	1.961	1.960	1.960	1.960
391	1.960	1.961	1.961	1.960	1.961
392	1.959	1.961	1.960	1.960	1.960
393	1.962	1.966	1.964	1.964	1.965
394	1.964	1.968	1.968	1.967	1.968
395	1.968	1.969	1.969	1.969	1.969
396	1.969	1.971	1.971	1.970	1.970
397	1.969	1.971	1.970	1.970	1.971
398	1.971	1.974	1.973	1.972	1.972
399	1.971	1.976	1.974	1.972	1.974
400	1.973	1.977	1.976	1.974	1.976
401	1.974	1.979	1.978	1.977	1.978
402	1.974	1.979	1.978	1.978	1.979
403	1.977	1.979	1.979	1.978	1.979
404	1.977	1.980	1.979	1.979	1.979
405	1.974	1.979	1.97[illegible]	1.977	1.978
406	2.331	2.337	2.335	2.333	2.337
407	2.333	2.340	2.339	2.338	2.339
408	2.336	2.341	2.340	2.339	2.340
409	2.338	2.342	2.341	2.340	2.341
410	2.339	2.343	2.343	2.341	2.343
411	2.339	2.344	2.343	2.341	2.343
412	2.339	2.343	2.343	2.341	2.342
413	2.340	2.344	2.342	2.341	2.343
414	2.340	2.347	2.344	2.342	2.344
415	2.341	2.348	2.347	2.344	2.348
416	2.342	2.349	2.348	2.347	2.349
417	2.344	2.350	2.349	2.348	2.349
418	2.344	2.350	2.350	2.349	2.349
419	1.438	1.438	1.438	1.438	1.438
420	1.434	1.435	1.435	1.434	1.434
421	1.433	1.433	1.433	1.433	1.433
422	1.431	1.432	1.432	1.431	1.431
423	1.430	1.430	1.430	1.430	1.431
424	1.428	1.426	1.428	1.428	1.428
425	1.428	1.429	1.429	1.429	1.429
426	1.428	1.428	1.428	1.428	1.428
427	1.425	1.427	1.427	1.427	1.426
428	1.422	1.423	1.422	1.422	1.422
429	1.423	1.423	1.423	1.423	1.423
430	1.422	1.423	1.423	1.423	1.423
431	1.422	1.422	1.422	1.422	1.422
432	1.971	1.974	1.973	1.973	1.973
433	1.972	1.974	1.973	1.973	1.973
434	1.973	1.975	1.975	1.973	1.974
435	1.971	1.973	1.973	1.972	1.973
436	1.971	1.973	1.973	1.972	1.973
437	1.970	1.972	1.971	1.971	1.971
438	1.965	1.969	1.969	1.968	1.968
439	1.966	1.969	1.968	1.968	1.968
440	1.965	1.969	1.968	1.968	1.968
441	1.965	1.969	1.968	1.968	1.968
442	1.967	1.969	1.968	1.968	1.969
443	1.967	1.969	1.969	1.969	1.969
444	1.968	1.969	1.969	1.969	1.969
445	1.929	1.931	1.930	1.930	1.930
446	1.931	1.934	1.932	1.932	1.932
447	1.934	1.939	1.936	1.936	1.936
448	1.938	1.940	1.939	1.939	1.939
449	1.939	1.941	1.941	1.941	1.941
450	1.942	1.946	1.944	1.944	1.944
451	1.944	1.948	1.947	1.946	1.946
452	1.945	1.948	1.948	1.948	1.948
453	1.948	1.950	1.950	1.950	1.950
454	1.949	1.951	1.950	1.950	1.950
455	1.949	1.951	1.950	1.950	1.950
456	1.949	1.951	1.950	1.950	1.950
457	1.949	1.951	1.950	1.950	1.950

TABLE F9 (continued)

458	1.965	1.967	1.968	1.967	1.968
459	1.967	1.968	1.968	1.969	1.969
460	1.967	1.968	1.968	1.968	1.969
461	1.967	1.968	1.968	1.968	1.969
462	1.968	1.968	1.969	1.968	1.969
463	1.968	1.969	1.969	1.969	1.969
464	1.969	1.969	1.969	1.969	1.969
465	1.968	1.969	1.969	1.969	1.969
466	1.968	1.969	1.969	1.969	1.969
467	1.968	1.969	1.969	1.969	1.969
468	1.969	1.969	1.969	1.969	1.969
469	1.968	1.969	1.969	1.969	1.969
470	1.964	1.967	1.967	1.967	1.968
471	1.960	1.961	1.961	1.961	1.961
472	1.959	1.959	1.960	1.960	1.960
473	1.955	1.955	1.957	1.955	1.957
474	1.955	1.955	1.956	1.955	1.958
475	1.953	1.954	1.954	1.954	1.956
476	1.954	1.954	1.954	1.954	1.954
477	1.954	1.954	1.954	1.954	1.954
478	1.953	1.953	1.953	1.952	1.953
479	1.952	1.952	1.952	1.951	1.952
480	1.947	1.947	1.948	1.948	1.947
481	1.945	1.946	1.947	1.947	1.948
482	1.947	1.947	1.947	1.947	1.947
483	1.947	1.948	1.948	1.947	1.948
484	2.024	2.024	2.024	2.024	2.024
485	2.024	2.024	2.024	2.024	2.024
486	2.024	2.024	2.026	2.024	2.024
487	2.024	2.024	2.024	2.025	2.024
488	2.023	2.023	2.024	2.022	2.022
489	2.023	2.023	2.024	2.023	2.023
490	2.023	2.023	2.024	2.022	2.022
491	2.022	2.022	2.023	2.022	2.022
492	2.022	2.022	2.023	2.022	2.022
493	2.021	2.021	2.021	2.021	2.021
494	2.021	2.021	2.021	2.021	2.021
495	2.021	2.021	2.021	2.021	2.021
496	2.020	2.020	2.021	2.020	2.020
497	1.672	1.672	1.672	1.672	1.672
498	1.672	1.672	1.672	1.672	1.672
499	1.671	1.671	1.671	1.671	1.671
500	1.671	1.671	1.671	1.671	1.671
501	1.670	1.670	1.671	1.670	1.670
502	1.671	1.671	1.671	1.670	1.670
503	1.669	1.669	1.669	1.669	1.669
504	1.669	1.669	1.669	1.669	1.669
505	1.669	1.669	1.670	1.670	1.670
506	1.670	1.670	1.670	1.670	1.670
507	1.670	1.670	1.670	1.670	1.670
508	1.669	1.669	1.669	1.669	1.669
509	1.669	1.669	1.670	1.670	1.670
510	2.020	2.020	2.020	2.020	2.020
511	2.021	2.021	2.021	2.021	2.021
512	2.021	2.021	2.021	2.021	2.021
513	2.021	2.021	2.021	2.021	2.021
514	2.021	2.021	2.021	2.021	2.021
515	2.022	2.022	2.022	2.022	2.022
516	2.022	2.022	2.023	2.022	2.022
517	2.022	2.022	2.022	2.022	2.022
518	2.021	2.021	2.021	2.021	2.021
519	2.024	2.024	2.024	2.024	2.024
520	2.024	2.024	2.026	2.024	2.024
521	2.024	2.025	2.025	2.025	2.025
522	2.026	2.025	2.026	2.024	2.024
523	1.971	1.970	1.970	1.969	1.969
524	1.971	1.970	1.970	1.969	1.969
525	1.971	1.970	1.970	1.969	1.969
526	1.970	1.966	1.969	1.968	1.968
527	1.970	1.968	1.969	1.968	1.968
528	1.970	1.968	1.969	1.967	1.967
529	1.970	1.968	1.969	1.967	1.967
530	1.970	1.968	1.969	1.967	1.967
531	1.970	1.968	1.969	1.967	1.967
532	1.969	1.967	1.967	1.965	1.965
533	1.969	1.967	1.967	1.967	1.967
534	1.969	1.967	1.967	1.964	1.964

TABLE F9 (continued)

535	1.969	1.967	1.967	1.965	1.965
536	2.079	2.079	2.080	2.079	2.079
537	2.079	2.079	2.080	2.079	2.079
538	2.079	2.079	2.080	2.079	2.079
539	2.079	2.079	2.080	2.079	2.079
540	2.079	2.079	2.080	2.079	2.080
541	2.080	2.080	2.080	2.079	2.079
542	2.080	2.080	2.081	2.080	2.080
543	2.081	2.081	2.081	2.080	2.080
544	4.342	4.376	4.406	4.356	4.356
545	4.350	4.383	4.413	4.360	4.361
546	4.354	4.389	4.419	4.366	4.366
547	4.358	4.390	4.420	4.369	4.368
548	4.358	4.390	4.419	4.368	4.368
549	1.728	1.728	1.729	1.728	1.728
550	1.729	1.729	1.729	1.729	1.729
551	1.730	1.730	1.730	1.730	1.730
552	1.731	1.732	1.732	1.731	1.731
553	1.731	1.732	1.733	1.731	1.731
554	1.732	1.732	1.734	1.732	1.732
555	1.733	1.734	1.736	1.732	1.732
556	1.980	1.980	1.980	1.980	1.980
557	1.980	1.980	1.981	1.980	1.980
558	1.980	1.982	1.982	1.980	1.980
559	1.980	1.982	1.984	1.981	1.981
560	1.981	1.982	1.983	1.981	1.981
561	1.981	1.983	1.984	1.981	1.981
562	1.980	1.982	1.983	1.980	1.980
563	1.680	1.680	1.681	1.680	1.680
564	1.680	1.680	1.681	1.680	1.680
565	1.680	1.680	1.681	1.680	1.680
566	1.681	1.681	1.682	1.681	1.681
567	1.681	1.682	1.683	1.681	1.681
568	2.259	2.261	2.263	2.260	2.260
569	2.262	2.267	2.269	2.263	2.263
570	2.267	2.269	2.270	2.267	2.267
571	2.268	2.271	2.272	2.269	2.269
572	2.270	2.273	2.274	2.271	2.271
573	2.272	2.277	2.279	2.274	2.274
574	2.273	2.277	2.279	2.274	2.274
575	2.273	2.277	2.279	2.274	2.274
576	2.564	2.569	2.571	2.567	2.567
577	2.567	2.570	2.573	2.568	2.568
578	2.567	2.571	2.573	2.569	2.569
579	2.567	2.571	2.573	2.569	2.569
580	2.568	2.571	2.574	2.569	2.569
581	2.569	2.572	2.575	2.570	2.570
582	2.569	2.573	2.577	2.570	2.570
583	2.569	2.573	2.578	2.572	2.572
584	2.442	2.443	2.447	2.443	2.443
585	2.440	2.442	2.444	2.442	2.442
586	2.440	2.441	2.443	2.441	2.441
587	2.438	2.439	2.440	2.440	2.440
588	2.437	2.438	2.440	2.440	2.440
589	3.334	3.338	3.343	3.340	3.341
590	3.334	3.338	3.342	3.339	3.339
591	3.330	3.333	3.339	3.334	3.334
592	3.329	3.331	3.337	3.332	3.332
593	3.328	3.330	3.337	3.331	3.330
594	3.328	3.330	3.337	3.331	3.331
595	4.607	4.611	4.623	4.614	4.614
596	4.606	4.610	4.622	4.613	4.613
597	4.604	4.610	4.622	4.613	4.613
598	4.606	4.611	4.623	4.614	4.614
599	2.922	2.925	2.930	2.927	2.927
600	2.923	2.926	2.930	2.928	2.928
601	2.923	2.928	2.931	2.928	2.928
602	2.926	2.929	2.932	2.930	2.930
603	2.929	2.930	2.936	2.932	2.932
604	2.930	2.932	2.938	2.933	2.933
605	2.417	2.420	2.423	2.419	2.419
606	2.418	2.420	2.423	2.420	2.420
607	2.419	2.422	2.426	2.421	2.421
608	2.420	2.421	2.426	2.421	2.421
609	2.420	2.422	2.425	2.421	2.421
610	2.420	2.422	2.427	2.422	2.422
611	2.898	2.900	2.907	2.900	2.900

TABLE F9 (continued)

612	2.899	2.901	2.909	2.901	2.901
613	2.900	2.903	2.910	2.902	2.902
614	2.901	2.903	2.911	2.903	2.903
615	2.903	2.907	2.913	2.904	2.904
616	2.904	2.907	2.913	2.907	2.907
617	3.330	3.332	3.340	3.330	3.330
618	3.330	3.333	3.342	3.331	3.331
619	3.331	3.334	3.343	3.332	3.332
620	3.333	3.338	3.347	3.335	3.335
621	3.337	3.340	3.349	3.339	3.339
622	3.338	3.341	3.350	3.340	3.340
623	4.639	4.640	4.657	4.637	4.637
624	4.647	4.649	4.664	4.643	4.645
625	4.651	4.651	4.669	4.649	4.649
626	4.653	4.653	4.670	4.650	4.650
627	4.656	4.657	4.673	4.652	4.652
628	4.661	4.662	4.679	4.658	4.658
629	2.675	2.678	2.683	2.678	2.678
630	2.677	2.679	2.684	2.678	2.678
631	2.678	2.680	2.684	2.679	2.679
632	2.678	2.680	2.686	2.679	2.679
633	2.679	2.681	2.686	2.680	2.680
634	2.680	2.683	2.688	2.681	2.681
635	2.793	2.795	2.799	2.791	2.791
636	2.793	2.796	2.799	2.793	2.793
637	2.795	2.797	2.800	2.793	2.793
638	2.796	2.798	2.800	2.794	2.794
639	2.798	2.799	2.801	2.797	2.797
640	2.798	2.799	2.802	2.798	2.798
641	3.067	3.069	3.073	3.064	3.064
642	3.069	3.070	3.074	3.068	3.068
643	3.070	3.071	3.074	3.068	3.068
644	3.070	3.070	3.076	3.068	3.068
645	3.070	3.071	3.076	3.069	3.069
646	3.070	3.072	3.077	3.069	3.069
647	3.507	3.509	3.513	3.503	3.503
648	3.508	3.509	3.514	3.504	3.504
649	3.509	3.509	3.514	3.509	3.509
650	3.509	3.509	3.516	3.504	3.504
651	3.509	3.509	3.517	3.506	3.506
652	3.509	3.509	3.517	3.508	3.508
653	4.025	4.027	4.034	4.022	4.022
654	4.028	4.029	4.035	4.021	4.021
655	4.028	4.029	4.037	4.022	4.022
656	4.028	4.029	4.037	4.022	4.022
657	4.028	4.029	4.037	4.022	4.022
658	4.029	4.030	4.038	4.023	4.023
659	5.801	5.794	5.812	5.782	5.782
660	5.801	5.796	5.813	5.783	5.783
661	5.802	5.797	5.813	5.783	5.783
662	5.803	5.798	5.814	5.784	5.784
663	5.805	5.798	5.816	5.786	5.786
664	5.806	5.799	5.820	5.779	5.779
665	1.574	1.574	1.577	1.576	1.576
666	1.574	1.576	1.578	1.576	1.576
667	1.576	1.578	1.579	1.578	1.578
668	1.578	1.579	1.580	1.579	1.579
669	1.579	1.579	1.581	1.580	1.580
670	1.720	1.721	1.724	1.722	1.722
671	1.722	1.723	1.726	1.722	1.722
672	1.723	1.724	1.728	1.724	1.724
673	1.722	1.724	1.728	1.724	1.724
674	1.723	1.724	1.729	1.725	1.725
675	2.095	2.098	2.106	2.099	2.100
676	2.096	2.099	2.107	2.100	2.100
677	2.098	2.100	2.109	2.101	2.101
678	2.099	2.101	2.109	2.102	2.102
679	1.694	1.694	1.696	1.695	1.695
680	1.694	1.696	1.697	1.696	1.696
681	1.695	1.696	1.697	1.696	1.696
682	1.696	1.698	1.698	1.697	1.697
683	1.698	1.697	1.699	1.698	1.698
684	1.698	1.698	1.699	1.698	1.698
685	1.931	1.933	1.934	1.932	1.932
686	1.932	1.934	1.936	1.933	1.933
687	1.933	1.934	1.937	1.933	1.933
688	1.933	1.935	1.938	1.934	1.934

TABLE F9 (continued)

689	1.934	1.936	1.939	1.936	1.936
690	1.937	1.938	1.939	1.937	1.937
691	2.231	2.233	2.235	2.232	2.232
692	2.232	2.234	2.238	2.234	2.234
693	2.234	2.237	2.240	2.236	2.236
694	2.234	2.236	2.239	2.235	2.235
695	2.233	2.237	2.239	2.234	2.234
696	2.234	2.237	2.239	2.234	2.234
697	2.550	2.550	2.553	2.550	2.550
698	2.550	2.552	2.556	2.552	2.552
699	2.552	2.553	2.559	2.553	2.553
700	2.552	2.554	2.559	2.553	2.553
701	2.553	2.557	2.560	2.555	2.555
702	2.553	2.556	2.560	2.553	2.553
703	1.675	1.676	1.677	1.678	1.678
704	1.678	1.676	1.679	1.679	1.679
705	1.678	1.679	1.679	1.679	1.679
706	1.679	1.679	1.679	1.679	1.679
707	1.679	1.680	1.680	1.679	1.679
708	1.680	1.680	1.681	1.680	1.680
709	1.902	1.903	1.903	1.903	1.903
710	1.904	1.904	1.907	1.903	1.903
711	1.906	1.906	1.907	1.906	1.906
712	1.906	1.907	1.908	1.907	1.907
713	1.906	1.907	1.908	1.907	1.907
714	1.907	1.908	1.909	1.908	1.908
715	2.229	2.230	2.230	2.230	2.230
716	2.229	2.230	2.231	2.230	2.230
717	2.229	2.230	2.231	2.230	2.230
718	2.230	2.231	2.232	2.231	2.231
719	2.230	2.232	2.233	2.232	2.232
720	2.231	2.232	2.233	2.232	2.232
721	1.677	1.677	1.678	1.678	1.678
722	1.679	1.679	1.679	1.679	1.679
723	1.679	1.680	1.680	1.679	1.679
724	1.680	1.681	1.681	1.681	1.681
725	1.680	1.681	1.681	1.681	1.681
726	1.682	1.682	1.682	1.682	1.682
727	1.900	1.900	1.900	1.900	1.900
728	1.900	1.901	1.902	1.900	1.900
729	1.901	1.902	1.902	1.902	1.902
730	1.902	1.903	1.903	1.902	1.902
731	1.902	1.903	1.903	1.902	1.902
732	1.902	1.903	1.904	1.903	1.903
733	2.216	2.218	2.219	2.217	2.217
734	2.217	2.219	2.219	2.217	2.217
735	2.217	2.219	2.220	2.218	2.218
736	2.219	2.220	2.221	2.219	2.219
737	2.219	2.220	2.221	2.220	2.220
738	2.220	2.222	2.222	2.220	2.220

TABLE F10

THE MEAN AND STD DEVIATION OF MILLIVOLT POSNS 28 TO32

K	XBAR	STD	TEMP	K	XBAR	STD	TEMP	K	XBAR	STD	TEMP
1	1.97580	0.00110	49.279	2	1.97860	0.00055	49.346	3	1.98060	0.00089	49.394
4	1.98260	0.00089	49.442	5	1.98340	0.00089	49.462	6	1.98400	0.00000	49.476
7	1.98400	0.00071	49.476	8	1.99140	0.00089	49.654	9	1.98600	0.00071	49.524
10	1.98560	0.00089	49.514	11	1.98620	0.00110	49.529	12	1.98760	0.00089	49.562
13	1.98720	0.00045	49.553	14	1.98780	0.00045	49.567	15	1.98200	0.00089	49.442
16	1.98280	0.00110	49.447	17	1.98380	0.00045	49.471	18	1.98400	0.00071	49.476
19	1.98420	0.00045	49.481	20	1.98380	0.00045	49.471	21	1.98380	0.00045	49.471
22	1.98380	0.00045	49.471	23	1.98660	0.00089	49.538	24	1.98620	0.00045	49.529
25	1.98640	0.00089	49.534	26	1.98580	0.00110	49.519	27	1.98520	0.00110	49.505
28	1.98540	0.00089	49.510	29	1.46200	0.00000	36.730	30	1.45800	0.00000	36.631
31	1.45540	0.00055	36.617	32	1.44800	0.00000	36.434	33	1.44600	0.00000	36.385
34	1.43400	0.00000	36.089	35	1.43600	0.00000	36.138	36	1.43800	0.00000	36.188
37	1.43700	0.00000	36.163	38	1.43880	0.00045	36.207	39	1.43980	0.00045	36.232
40	1.44000	0.00000	36.237	41	1.44100	0.00000	36.262	42	1.44080	0.00045	36.257
43	2.37000	0.00141	58.655	44	2.36680	0.00390	58.580	45	2.36920	0.00110	58.636
46	2.36980	0.00110	58.650	47	2.37000	0.00122	58.655	48	2.36920	0.00110	58.636
49	2.36900	0.00071	58.632	50	2.37440	0.00114	58.759	51	2.37420	0.00110	58.754
52	2.37420	0.00110	58.754	53	2.37280	0.00110	58.721	54	2.37060	0.00114	58.669
55	2.37040	0.00089	58.665	56	2.03180	0.00110	50.622	57	2.02820	0.00084	50.536
58	2.02380	0.00045	50.430	59	2.02120	0.00110	50.366	60	2.01940	0.00055	50.325
61	2.04000	0.00071	50.818	62	2.03640	0.00089	50.732	63	2.03340	0.00134	50.660
64	2.03180	0.00110	50.622	65	2.03080	0.00045	50.596	66	2.02760	0.00089	50.521
67	2.02680	0.00110	50.502	68	2.02620	0.00084	50.488	69	2.02100	0.00071	50.363
70	2.01980	0.00045	50.335	71	2.01940	0.00134	50.325	72	2.01800	0.00071	50.291
73	2.01800	0.00071	50.291	74	2.01440	0.00114	50.205	75	2.01060	0.00089	50.114
76	2.01080	0.00045	50.119	77	2.00980	0.00045	50.095	78	2.00560	0.00152	49.994
79	2.00780	0.00110	50.047	80	2.00860	0.00089	50.066	81	1.96800	0.00071	49.092
82	1.95760	0.00152	48.842	83	1.96360	0.00089	48.986	84	1.96060	0.00055	48.914
85	1.95660	0.00152	48.818	86	1.95520	0.00179	48.784	87	1.95560	0.00114	48.794
88	1.97560	0.00152	49.274	89	1.96880	0.00089	49.106	90	1.96200	0.00071	48.948
91	1.96020	0.00045	48.904	92	1.95980	0.00045	48.895	93	1.96400	0.00100	48.996
94	1.43100	0.00000	36.015	95	1.43700	0.00000	36.163	96	1.43600	0.00000	36.138
97	1.44100	0.00000	36.262	98	1.44100	0.00000	36.262	99	1.44000	0.00000	36.237
100	1.43900	0.00000	36.212	101	1.43100	0.00000	36.015	102	1.43900	0.00000	36.212
103	1.43900	0.00000	36.212	104	1.43900	0.00000	36.212	105	1.43900	0.00000	36.212
106	1.43740	0.00055	36.173	107	2.35080	0.00110	58.203	108	2.34700	0.00157	58.113
109	2.33900	0.00071	57.924	110	2.35300	0.00122	58.254	111	2.34620	0.00192	58.094
112	2.34020	0.00084	57.953	113	2.33660	0.00219	57.868	114	2.33000	0.00071	57.712
115	2.32840	0.00134	57.674	116	2.32420	0.00217	57.575	117	2.32100	0.00071	57.499
118	2.31360	0.00179	57.329	119	2.31180	0.00110	57.282	120	1.97880	0.00045	49.351
121	1.97580	0.00110	49.279	122	1.96980	0.00045	49.135	123	1.96660	0.00114	49.058
124	1.95980	0.00045	48.895	125	1.95880	0.00045	48.871	126	1.95560	0.00110	48.799
127	1.95780	0.00110	48.847	128	1.97560	0.00114	49.274	129	1.97120	0.00045	49.169
130	1.96980	0.00045	49.135	131	1.96620	0.00179	49.046	132	1.96000	0.00071	48.899
133	1.98280	0.00110	49.447	134	1.98040	0.00055	49.389	135	1.97800	0.00045	49.351
136	1.98320	0.00084	49.457	137	1.97940	0.00055	49.365	138	1.96200	0.00071	48.948
139	1.98680	0.00130	49.543	140	1.98080	0.00045	49.399	141	1.97580	0.00084	49.279
142	1.97100	0.00071	49.104	143	1.96680	0.00110	49.063	144	1.96200	0.00071	48.948
145	1.96100	0.00071	48.923	146	1.96180	0.00045	48.943	147	1.96020	0.00045	48.904
148	1.95700	0.00071	48.827	149	1.95700	0.00071	48.827	150	1.95560	0.00089	48.794
151	1.95300	0.00071	48.731	152	1.95140	0.00089	48.693	153	1.95100	0.00071	48.683
154	1.94940	0.00055	48.645	155	1.94980	0.00045	48.654	156	1.94920	0.00045	48.640
157	1.96220	0.00045	48.952	158	1.96000	0.00000	48.899	159	1.93280	0.00110	48.245
160	1.92920	0.00045	48.159	161	1.92700	0.00167	48.100	162	1.92100	0.00071	47.961
163	1.92020	0.00084	47.942	164	1.91820	0.00084	47.894	165	1.91620	0.00148	47.846
166	1.90900	0.00071	47.672	167	1.90860	0.00089	47.663	168	1.90300	0.00071	47.526
169	1.90340	0.00114	47.537	170	1.90780	0.00110	47.643	171	1.90820	0.00130	47.653
172	1.41400	0.00000	35.595	173	1.41100	0.00000	35.521	174	1.40900	0.00000	35.471
175	1.40800	0.00000	35.447	176	1.40500	0.00000	35.372	177	1.40440	0.00055	35.358
178	1.40300	0.00000	35.323	179	1.40400	0.00000	35.348	180	1.40460	0.00055	35.363
181	1.40700	0.00000	35.422	182	1.40500	0.00000	35.372	183	1.40600	0.00000	35.397
184	1.40500	0.00000	35.372	185	2.23180	0.00148	55.388	186	2.23860	0.00084	55.554
187	2.23760	0.00152	55.526	188	2.25700	0.00235	55.986	189	2.24180	0.00148	55.625
190	2.27880	0.00110	56.502	191	2.26880	0.00110	56.265	192	2.26000	0.00122	56.057
193	2.24460	0.00251	55.692	194	2.24180	0.00148	55.625	195	2.23720	0.00192	55.516
196	2.23740	0.00195	55.521	197	2.23880	0.00110	55.554	198	1.93140	0.00089	48.212
199	1.92880	0.00045	48.149	200	1.92760	0.00152	48.120	201	1.92440	0.00114	48.043
202	1.92200	0.00071	47.985	203	1.92000	0.00071	47.937	204	1.91980	0.00045	47.932
205	1.91920	0.00084	47.918	206	1.91960	0.00071	47.913	207	1.91600	0.00152	47.855
208	1.91640	0.00195	47.850	209	1.91520	0.00148	47.822	210	1.90980	0.00045	47.691
211	1.90820	0.00084	47.653	212	1.90900	0.00071	47.672	213	1.90800	0.00114	47.648

214	1.90900	0.00071	47.672	215	1.90860	0.00114	47.663	216	1.92840	0.00089	48.139
217	1.92420	0.00179	48.038	218	1.92140	0.00055	47.971	219	1.91920	0.00084	47.918
220	1.91660	0.00207	47.855	221	1.91520	0.00179	47.822	222	1.91220	0.00130	47.749
223	1.90900	0.00071	47.672	224	1.90500	0.00158	47.576	225	1.90520	0.00140	47.581
226	1.90280	0.00084	47.523	227	1.90580	0.00192	47.595	228	1.90820	0.00164	47.655
229	1.89960	0.00055	47.446	230	1.90080	0.00084	47.475	231	1.90080	0.00084	47.475
232	1.90720	0.00148	47.629	233	1.90820	0.00084	47.653	234	1.90880	0.00110	47.667
235	1.90860	0.00089	47.663	236	1.90900	0.00071	47.672	237	1.90000	0.00071	47.455
238	1.89780	0.00110	47.402	239	1.89480	0.00179	47.330	240	1.89340	0.00089	47.296
241	1.89960	0.00055	47.446	242	1.90020	0.00084	47.460	243	1.90020	0.00084	47.460
244	1.90020	0.00110	47.460	245	1.90080	0.00130	47.475	246	1.90040	0.00114	47.465
247	1.90100	0.00071	47.479	248	1.90140	0.00089	47.489	249	1.90140	0.00089	47.489
250	1.40520	0.00045	35.377	251	1.40580	0.00045	35.392	252	1.40400	0.00000	35.348
253	1.40380	0.00045	35.343	254	1.40320	0.00045	35.328	255	1.40200	0.00000	35.298
256	1.40200	0.00000	35.298	257	1.40200	0.00000	35.298	258	1.40100	0.00000	35.274
259	1.40000	0.00000	35.249	260	1.40000	0.00000	35.249	261	1.40060	0.00055	35.264
262	1.40100	0.00000	35.274	263	2.23020	0.00148	55.350	264	2.23140	0.00152	55.379
265	2.23460	0.00270	55.455	266	2.23620	0.00249	55.493	267	2.23700	0.00235	55.512
268	2.23740	0.00207	55.521	269	2.23700	0.00235	55.512	270	2.23920	0.00130	55.564
271	2.23920	0.00130	55.564	272	2.23940	0.00152	55.569	273	2.23900	0.00122	55.559
274	2.23720	0.00249	55.516	275	2.23760	0.00207	55.526	276	1.94000	0.00071	48.419
277	1.93940	0.00055	48.404	278	1.93920	0.00045	48.399	279	1.93740	0.00114	48.356
280	1.93660	0.00114	48.337	281	1.93380	0.00148	48.269	282	1.93180	0.00084	48.221
283	1.92840	0.00089	48.139	284	1.92820	0.00045	48.135	285	1.92860	0.00055	48.144
286	1.93000	0.00071	48.178	287	1.93100	0.00071	48.202	288	1.93060	0.00089	48.192
289	1.94300	0.00071	48.491	290	1.94440	0.00152	48.524	291	1.94360	0.00089	48.505
292	1.94320	0.00110	48.496	293	1.96460	0.00152	49.010	294	1.96200	0.00071	48.948
295	1.95900	0.00071	48.875	296	1.95480	0.00179	48.774	297	1.95140	0.00089	48.693
298	1.94240	0.00055	48.476	299	1.94300	0.00071	48.491	300	1.94140	0.00089	48.452
301	1.94100	0.00071	48.443	302	1.93680	0.00110	48.342	303	1.93680	0.00110	48.342
304	1.93140	0.00055	48.212	305	1.93200	0.00071	48.226	306	1.93200	0.00071	48.226
307	1.92600	0.00141	48.082	308	1.92680	0.00110	48.101	309	1.92760	0.00089	48.120
310	1.92880	0.00045	48.149	311	1.92920	0.00045	48.159	312	1.92920	0.00045	48.159
313	1.92920	0.00045	48.159	314	1.92880	0.00045	48.149	315	1.95320	0.00084	48.736
316	1.95620	0.00192	48.808	317	1.95760	0.00114	48.842	318	1.95820	0.00130	48.856
319	1.95840	0.00089	48.861	320	1.95940	0.00089	48.885	321	1.95940	0.00089	48.885
322	1.96040	0.00089	48.909	323	1.96080	0.00130	48.919	324	1.96100	0.00071	48.923
325	1.96100	0.00071	48.923	326	1.96420	0.00148	49.000	327	1.96540	0.00182	49.029
328	1.42400	0.00000	35.842	329	1.42460	0.00055	35.857	330	1.42400	0.00000	35.842
331	1.42400	0.00000	35.842	332	1.42400	0.00000	35.842	333	1.42400	0.00000	35.842
334	1.42380	0.00045	35.837	335	1.42280	0.00045	35.812	336	1.42300	0.00000	35.817
337	1.42380	0.00045	35.837	338	1.42300	0.00000	35.817	339	1.42400	0.00000	35.842
340	1.42400	0.00000	35.842	341	2.35480	0.00192	58.297	342	2.34760	0.00219	58.127
343	2.34220	0.00148	58.000	344	2.33580	0.00239	57.849	345	2.33220	0.00164	57.764
346	2.33080	0.00114	57.726	347	2.32940	0.00089	57.698	348	2.32280	0.00167	57.537
349	2.32340	0.00152	57.556	350	2.32380	0.00192	57.565	351	2.32400	0.00224	57.570
352	2.32600	0.00255	57.617	353	2.32720	0.00249	57.646	354	1.99000	0.00071	49.620
355	1.98780	0.00179	49.567	356	1.98560	0.00195	49.514	357	1.98200	0.00100	49.428
358	1.98080	0.00084	49.399	359	1.97940	0.00089	49.365	360	1.97440	0.00152	49.245
361	1.97680	0.00179	49.303	362	1.97580	0.00164	49.279	363	1.97100	0.00071	49.164
364	1.97220	0.00084	49.193	365	1.97260	0.00114	49.202	366	1.95520	0.00164	48.784
367	1.95840	0.00134	48.861	368	1.95900	0.00071	48.875	369	1.95980	0.00045	48.895
370	1.96020	0.00084	48.904	371	1.96180	0.00045	48.943	372	1.96200	0.00071	48.948
373	1.96220	0.00084	48.952	374	1.96100	0.00071	48.923	375	1.96100	0.00071	48.923
376	1.96020	0.00130	48.904	377	1.96080	0.00045	48.919	378	1.96080	0.00045	48.919
379	1.96120	0.00045	48.928	380	1.98260	0.00089	49.442	381	1.98020	0.00045	49.385
382	1.97860	0.00055	49.346	383	1.97540	0.00167	49.269	384	1.97180	0.00084	49.183
385	1.96920	0.00045	49.121	386	1.96900	0.00071	49.116	387	1.96820	0.00084	49.097
388	1.96780	0.00110	49.087	389	1.96660	0.00152	49.058	390	1.96020	0.00045	48.904
391	1.96060	0.00055	48.914	392	1.96000	0.00071	48.899	393	1.96420	0.00140	49.000
394	1.96700	0.00173	49.068	395	1.96880	0.00045	49.111	396	1.97020	0.00084	49.145
397	1.97020	0.00084	49.145	398	1.97240	0.00114	49.197	399	1.97340	0.00195	49.221
400	1.97520	0.00164	49.265	401	1.97720	0.00192	49.313	402	1.97760	0.00207	49.322
403	1.97840	0.00089	49.341	404	1.97880	0.00110	49.351	405	1.97720	0.00192	49.313
406	2.33460	0.00261	57.820	407	2.33780	0.00277	57.896	408	2.33920	0.00192	57.929
409	2.34040	0.00152	57.957	410	2.34180	0.00179	57.990	411	2.34200	0.00200	57.995
412	2.34160	0.00167	57.986	413	2.34200	0.00158	57.995	414	2.34340	0.00261	58.028
415	2.34560	0.00305	58.080	416	2.34700	0.00292	58.113	417	2.34800	0.00235	58.136
418	2.34840	0.00251	58.146	419	1.43800	0.00000	36.188	420	1.43240	0.00055	36.049
421	1.43300	0.00000	36.064	422	1.43140	0.00055	36.025	423	1.43020	0.00045	35.995
424	1.42800	0.00000	35.941	425	1.42880	0.00045	35.960	426	1.42800	0.00000	35.941
427	1.42640	0.00089	35.901	428	1.42220	0.00045	35.797	429	1.42300	0.00000	35.817
430	1.42280	0.00045	35.812	431	1.42200	0.00000	35.793	432	1.97280	0.00110	49.207
433	1.97300	0.00071	49.212	434	1.97400	0.00100	49.236	435	1.97240	0.00089	49.197
436	1.97240	0.00089	49.197	437	1.97100	0.00071	49.164	438	1.96780	0.00164	49.087
439	1.96780	0.00110	49.087	440	1.96760	0.00152	49.082	441	1.96760	0.00152	49.082
442	1.96820	0.00084	49.097	443	1.96860	0.00089	49.100	444	1.96880	0.00045	49.111

TABLE F10 (continued)

445	1.93000	0.00071	48.178	446	1.93220	0.00110	48.231	447	1.93620	0.00179	48.327
448	1.93900	0.00071	48.395	449	1.94060	0.00069	48.433	450	1.94400	0.00141	48.515
451	1.94620	0.00148	48.508	452	1.94740	0.00134	48.597	453	1.94960	0.00089	48.649
454	1.95000	0.00071	48.659	455	1.95000	0.00071	48.659	456	1.95000	0.00071	48.659
457	1.95000	0.00071	48.659	458	1.96700	0.00122	49.066	459	1.96820	0.00084	49.097
460	1.96800	0.00071	49.092	461	1.96800	0.00071	49.092	462	1.96840	0.00055	49.101
463	1.96880	0.00045	49.111	464	1.96900	0.00000	49.116	465	1.96880	0.00045	49.111
466	1.96880	0.00045	49.111	467	1.96880	0.00045	49.111	468	1.96900	0.00000	49.116
469	1.96880	0.00045	49.111	470	1.96660	0.00152	49.056	471	1.96060	0.00045	48.919
472	1.95960	0.00055	48.890	473	1.95580	0.00110	48.799	474	1.95580	0.00130	48.799
475	1.95420	0.00110	48.760	476	1.95400	0.00000	48.755	477	1.95400	0.00000	48.755
478	1.95280	0.00045	48.726	479	1.95180	0.00045	48.702	480	1.94740	0.00055	48.597
481	1.94660	0.00114	48.577	482	1.94700	0.00000	48.587	483	1.94760	0.00055	48.601
484	2.02400	0.00000	50.435	485	2.02400	0.00000	50.435	486	2.02440	0.00089	50.445
487	2.02420	0.00045	50.440	488	2.02280	0.00084	50.406	489	2.02320	0.00045	50.416
490	2.02280	0.00084	50.406	491	2.02220	0.00045	50.392	492	2.02220	0.00045	50.392
493	2.02100	0.00000	50.363	494	2.02100	0.00000	50.363	495	2.02100	0.00000	50.363
496	2.02020	0.00045	50.344	497	1.67200	0.00000	41.926	498	1.67200	0.00000	41.926
499	1.67100	0.00000	41.903	500	1.67100	0.00000	41.903	501	1.67020	0.00045	41.884
502	1.67060	0.00055	41.894	503	1.66900	0.00000	41.855	504	1.66900	0.00000	41.855
505	1.66960	0.00055	41.869	506	1.67000	0.00000	41.879	507	1.67000	0.00000	41.879
508	1.66900	0.00000	41.855	509	1.66960	0.00055	41.869	510	2.02000	0.00000	50.339
511	2.02100	0.00000	50.363	512	2.02100	0.00000	50.363	513	2.02100	0.00000	50.363
514	2.02100	0.00000	50.363	515	2.02200	0.00000	50.387	516	2.02220	0.00045	50.392
517	2.02200	0.00000	50.387	518	2.02100	0.00000	50.363	519	2.02400	0.00000	50.435
520	2.02440	0.00089	50.445	521	2.02480	0.00045	50.454	522	2.02500	0.00100	50.459
523	1.96980	0.00084	49.135	524	1.96980	0.00084	49.135	525	1.96980	0.00084	49.135
526	1.96860	0.00089	49.106	527	1.96860	0.00089	49.106	528	1.96820	0.00130	49.097
529	1.96820	0.00130	49.097	530	1.96820	0.00130	49.097	531	1.96820	0.00130	49.097
532	1.96660	0.00167	49.058	533	1.96740	0.00089	49.077	534	1.96620	0.00217	49.048
535	1.96660	0.00167	49.058	536	2.07920	0.00045	51.756	537	2.07920	0.00045	51.756
538	2.07920	0.00045	51.756	539	2.07920	0.00045	51.756	540	2.07940	0.00055	51.761
541	2.07960	0.00055	51.765	542	2.08020	0.00045	51.780	543	2.08060	0.00055	51.789
544	4.36720	0.02434	103.863	545	4.37340	0.02521	103.796	546	4.37880	0.02530	103.913
547	4.38100	0.02472	103.961	548	4.38060	0.02445	103.952	549	1.72820	0.00045	43.296
550	1.72900	0.00000	43.316	551	1.73000	0.00000	43.340	552	1.73140	0.00055	43.374
553	1.73160	0.00089	43.379	554	1.73240	0.00089	43.398	555	1.73340	0.00137	43.423
556	1.98000	0.00000	49.380	557	1.98020	0.00045	49.385	558	1.98080	0.00110	49.399
559	1.98160	0.00152	49.418	560	1.98160	0.00069	49.416	561	1.98200	0.00141	49.428
562	1.98100	0.00141	49.404	563	1.68020	0.00045	42.128	564	1.68020	0.00045	42.128
565	1.68020	0.00045	42.128	566	1.68120	0.00045	42.152	567	1.68100	0.00089	42.152
568	2.26000	0.00152	56.071	569	2.26480	0.00303	56.170	570	2.26800	0.00141	56.246
571	2.26980	0.00164	56.289	572	2.27180	0.00164	56.336	573	2.27520	0.00277	56.417
574	2.27540	0.00251	56.421	575	2.27540	0.00251	56.421	576	2.56780	0.00282	63.289
577	2.56920	0.00239	63.326	578	2.56980	0.00226	63.340	579	2.56980	0.00226	63.340
580	2.57020	0.00239	63.349	581	2.57120	0.00239	63.373	582	2.57160	0.00327	63.387
583	2.57280	0.00327	63.410	584	2.44360	0.00195	60.386	585	2.44200	0.00141	60.348
586	2.44120	0.00110	60.330	587	2.43940	0.00089	60.287	588	2.43900	0.00141	60.278
589	3.33920	0.00342	80.986	590	3.33840	0.00268	80.967	591	3.33400	0.00324	80.868
592	3.33220	0.00295	80.828	593	3.33120	0.00342	80.805	594	3.33140	0.00336	80.810
595	4.61300	0.00589	108.962	596	4.61280	0.00569	108.941	597	4.61240	0.00650	108.932
598	4.61360	0.00619	108.958	599	2.92620	0.00295	71.590	600	2.92700	0.00265	71.608
601	2.92760	0.00268	71.622	602	2.92940	0.00219	71.663	603	2.93160	0.00266	71.719
604	2.93320	0.00295	71.751	605	2.41960	0.00219	59.822	606	2.42020	0.00179	59.836
607	2.42180	0.00259	59.874	608	2.42180	0.00239	59.874	609	2.42180	0.00192	59.874
610	2.42260	0.00261	59.893	611	2.90100	0.00346	71.011	612	2.90220	0.00390	71.039
613	2.90340	0.00385	71.066	614	2.90420	0.00390	71.085	615	2.90620	0.00409	71.131
616	2.90760	0.00329	71.163	617	3.33240	0.00434	80.832	618	3.33340	0.00493	80.855
619	3.33440	0.00493	80.877	620	3.33760	0.00555	80.949	621	3.34060	0.00471	81.022
622	3.34180	0.00471	81.044	623	4.64200	0.00849	109.565	624	4.64960	0.00635	109.727
625	4.65380	0.00656	109.817	626	4.65520	0.00841	109.847	627	4.65800	0.00669	109.907
628	4.66300	0.00879	110.026	629	2.67840	0.00268	65.860	630	2.67920	0.00277	65.857
631	2.68000	0.00235	65.905	632	2.68040	0.00321	65.915	633	2.68120	0.00277	65.923
634	2.68200	0.00321	65.966	635	2.79380	0.00335	68.541	636	2.79480	0.00260	68.565
637	2.79560	0.00297	68.583	638	2.79640	0.00261	68.601	639	2.79840	0.00167	68.647
640	2.79900	0.00173	68.661	641	3.06740	0.00378	74.822	642	3.07080	0.00249	74.876
643	3.07020	0.00249	74.866	644	3.07040	0.00329	74.890	645	3.07100	0.00292	74.904
646	3.07140	0.00336	74.913	647	3.50700	0.00424	84.754	648	3.50760	0.00415	84.772
649	3.51000	0.00224	84.822	650	3.50840	0.00493	84.786	651	3.50940	0.00451	84.808
652	3.51020	0.00383	84.826	653	4.02600	0.00495	96.243	654	4.02680	0.00593	96.261
655	4.02760	0.00619	96.278	656	4.02760	0.00619	96.278	657	4.02760	0.00619	96.278
658	4.02860	0.00619	96.300	659	5.79420	0.01265	133.646	660	5.79520	0.01274	133.669
661	5.79560	0.01288	133.677	662	5.79660	0.01288	133.697	663	5.79820	0.01285	133.730
664	5.79660	0.01776	133.697	665	1.57540	0.00134	39.567	666	1.57500	0.00141	39.551
667	1.57780	0.00110	39.625	668	1.57900	0.00071	39.655	669	1.57960	0.00084	39.674
670	1.72180	0.00148	43.141	671	1.72300	0.00173	43.170	672	1.72460	0.00195	43.209
673	1.72440	0.00219	43.204	674	1.72520	0.00228	43.223	675	2.09960	0.00404	52.243

TABLE F10 (continued)

676	2.10040	0.00404	52.262	677	2.10180	0.00421	52.296	678	2.10260	0.00376	52.315
679	1.69480	0.00084	42.463	680	1.69580	0.00110	42.508	681	1.69600	0.00071	42.513
682	1.69720	0.00064	42.542	683	1.69800	0.00071	42.561	684	1.69820	0.00045	42.566
685	1.93240	0.00114	48.236	686	1.93360	0.00152	48.265	687	1.93400	0.00173	48.274
688	1.93480	0.00192	48.293	689	1.93620	0.00179	48.327	690	1.93760	0.00089	48.361
691	2.23200	0.00152	55.407	692	2.23440	0.00219	55.450	693	2.23600	0.00219	55.502
694	2.23580	0.00192	55.403	695	2.23540	0.00251	55.474	696	2.23560	0.00230	55.478
697	2.55000	0.00134	62.892	698	2.55240	0.00219	62.934	699	2.55400	0.00283	62.971
700	2.55420	0.00277	62.976	701	2.55600	0.00265	63.018	702	2.55500	0.00306	62.995
703	1.67680	0.00130	42.045	704	1.67560	0.00055	42.089	705	1.67580	0.00045	42.094
706	1.67900	0.00000	42.098	707	1.67940	0.00055	42.108	708	1.68020	0.00045	42.128
709	1.90260	0.00045	47.523	710	1.90420	0.00164	47.557	711	1.90620	0.00045	47.605
712	1.90700	0.00071	47.624	713	1.90700	0.00071	47.624	714	1.90800	0.00071	47.648
715	2.22980	0.00045	55.341	716	2.23000	0.00071	55.346	717	2.23000	0.00071	55.346
718	2.23100	0.00071	55.369	719	2.23180	0.00110	55.388	720	2.23200	0.00071	55.393
721	1.67760	0.00055	42.064	722	1.67900	0.00000	42.098	723	1.67940	0.00055	42.108
724	1.68080	0.00045	42.142	725	1.68080	0.00045	42.142	726	1.68200	0.00000	42.172
727	1.90000	0.00000	47.455	728	1.90060	0.00009	47.470	729	1.90160	0.00045	47.499
730	1.90240	0.00055	47.513	731	1.90240	0.00055	47.513	732	1.90300	0.00071	47.528
733	2.21740	0.00114	55.047	734	2.21780	0.00110	55.056	735	2.21840	0.00114	55.070
736	2.21960	0.00089	55.099	737	2.22000	0.00071	55.106	738	2.22060	0.00110	55.127

TABLE F11

Raw Experimental Data

Current (amps) and Voltage (volts

THE CURRENT AND VOLTAGE READ IN ARE

K	AMPS1	AMPS2	VOLTS1	VOLTS2
1	0.5187	0.5189	35.420	35.430
2	0.5190	0.5190	35.440	35.450
3	0.5192	0.5191	35.450	35.460
4	0.5191	0.5189	35.460	35.450
5	0.5191	0.5190	35.450	35.440
6	0.5190	0.5189	35.440	35.430
7	0.5190	0.5189	35.440	35.430
8	0.5188	0.5188	35.420	35.420
9	0.5189	0.5187	35.420	35.420
10	0.5189	0.5188	35.440	35.430
11	0.5186	0.5189	35.430	35.450
12	0.5185	0.5186	35.430	35.430
13	0.5182	0.5183	35.400	35.410
14	0.5182	0.5181	35.400	35.400
15	0.5166	0.5179	35.460	35.460
16	0.5183	0.5182	35.460	35.460
17	0.5181	0.5182	35.460	35.460
18	0.5179	0.5178	35.440	35.440
19	0.5177	0.5177	35.450	35.450
20	0.5175	0.5176	35.440	35.440
21	0.5176	0.5175	35.430	35.440
22	0.5173	0.5176	35.440	35.460
23	0.5176	0.5174	35.460	35.450
24	0.5174	0.5174	35.450	35.450
25	0.5171	0.5173	35.420	35.440
26	0.5171	0.5172	35.420	35.430
27	0.5171	0.5172	35.430	35.430
28	0.5171	0.5173	35.430	35.430
29	0.2469	0.2467	17.020	17.020
30	0.2473	0.2469	17.020	17.020
31	0.2470	0.2474	17.030	17.030
32	0.2476	0.2476	17.020	17.030
33	0.2477	0.2478	17.030	17.030
34	0.2496	0.2482	17.070	17.070
35	0.2465	0.2452	17.080	17.080

TABLE F11 (continued)

36	0.2449	0.2445	17.090	17.090
37	0.2441	0.2435	17.090	17.060
38	0.2479	0.2480	17.090	17.090
39	0.2480	0.2464	17.090	17.060
40	0.2456	0.2452	17.070	17.080
41	0.2467	0.2461	17.080	17.090
42	0.2471	0.2472	17.090	17.090
43	0.6551	0.6551	44.610	44.610
44	0.6550	0.6549	44.590	44.590
45	0.6550	0.6551	44.600	44.590
46	0.6548	0.6550	44.580	44.590
47	0.6551	0.6548	44.590	44.560
48	0.6548	0.6547	44.570	44.560
49	0.6548	0.6548	44.570	44.560
50	0.6554	0.6554	44.620	44.610
51	0.6552	0.6552	44.630	44.630
52	0.6549	0.6549	44.600	44.610
53	0.6544	0.6547	44.570	44.590
54	0.6542	0.6546	44.560	44.590
55	0.6545	0.6544	44.580	44.580
56	0.5204	0.5206	35.510	35.520
57	0.5204	0.5205	35.510	35.510
58	0.5203	0.5203	35.510	35.500
59	0.5202	0.5203	35.500	35.500
60	0.5198	0.5193	35.500	35.510
61	0.5220	0.5230	35.480	35.480
62	0.5230	0.5230	35.480	35.480
63	0.5230	0.5220	35.470	35.470
64	0.5230	0.5230	35.470	35.470
65	0.5220	0.5230	35.480	35.460
66	0.5210	0.5220	35.470	35.470
67	0.5220	0.5220	35.460	35.460
68	0.5210	0.5220	35.470	35.460
69	0.5210	0.5200	35.420	35.420
70	0.5200	0.5200	35.430	35.430
71	0.5200	0.5200	35.440	35.450
72	0.5210	0.5210	35.450	35.450
73	0.5200	0.5200	35.460	35.440
74	0.5200	0.5190	35.440	35.430

TABLE F11 (continued)

75	0.5200	0.5190	35.440	35.450
76	0.5200	0.5200	35.450	35.460
77	0.5200	0.5200	35.460	35.460
78	0.5190	0.5190	35.420	35.430
79	0.5200	0.5190	35.440	35.440
80	0.5200	0.5200	35.450	35.450
81	0.5160	0.5160	35.420	35.430
82	0.5170	0.5160	35.450	35.450
83	0.5160	0.5160	35.430	35.430
84	0.5160	0.5160	35.420	35.420
85	0.5160	0.5160	35.440	35.440
86	0.5160	0.5160	35.440	35.450
87	0.5160	0.5160	35.430	35.450
88	0.5160	0.5150	35.440	35.430
89	0.5150	0.5150	35.420	35.420
90	0.5150	0.5160	35.420	35.420
91	0.5160	0.5160	35.440	35.450
92	0.5170	0.5180	35.460	35.460
93	0.5180	0.5170	35.460	35.460
94	0.2480	0.2480	17.050	17.050
95	0.2480	0.2480	17.040	17.040
96	0.2480	0.2480	17.050	17.050
97	0.2440	0.2440	17.040	17.040
98	0.2430	0.2440	17.050	17.050
99	0.2430	0.2440	17.050	17.050
100	0.2440	0.2440	17.050	17.060
101	0.2440	0.2430	17.040	17.040
102	0.2460	0.2460	17.040	17.050
103	0.2460	0.2470	17.050	17.050
104	0.2470	0.2460	17.060	17.050
105	0.2460	0.2460	17.060	17.050
106	0.2460	0.2470	17.060	17.050
107	0.6520	0.6510	44.610	44.600
108	0.6510	0.6520	44.600	44.600
109	0.6510	0.6500	44.580	44.590
110	0.6500	0.6530	44.600	44.620
111	0.6510	0.6510	44.590	44.610
112	0.6510	0.6500	44.590	44.560

TABLE F11 (continued)

113	0.6510	0.6500	44.600	44.600
114	0.6510	0.6500	44.600	44.590
115	0.6500	0.6500	44.590	44.590
116	0.6500	0.6500	44.560	44.570
117	0.6510	0.6510	44.570	44.590
118	0.6500	0.6500	44.610	44.600
119	0.6510	0.6510	44.590	44.610
120	0.5160	0.5150	35.450	35.460
121	0.5160	0.5150	35.460	35.440
122	0.5150	0.5160	35.450	35.440
123	0.5160	0.5160	35.460	35.450
124	0.5160	0.5150	35.440	35.440
125	0.5160	0.5150	35.440	35.440
126	0.5160	0.5160	35.440	35.430
127	0.5150	0.5150	35.440	35.430
128	0.5150	0.5160	35.430	35.440
129	0.5150	0.5160	35.440	35.450
130	0.5160	0.5150	35.460	35.450
131	0.5150	0.5160	35.450	35.450
132	0.5150	0.5160	35.440	35.440
133	0.5190	0.5200	35.420	35.430
134	0.5190	0.5180	35.430	35.420
135	0.5200	0.5190	35.420	35.430
136	0.5200	0.5200	35.440	35.450
137	0.5190	0.5200	35.420	35.430
138	0.5190	0.5190	35.410	35.410
139	0.5190	0.5190	35.410	35.410
140	0.5140	0.5150	35.440	35.450
141	0.5140	0.5170	35.420	35.420
142	0.5150	0.5150	35.410	35.410
143	0.5160	0.5160	35.420	35.420
144	0.5170	0.5170	35.410	35.410
145	0.5160	0.5160	35.410	35.410
146	0.5210	0.5210	35.480	35.480
147	0.5200	0.5190	35.470	35.470
148	0.5200	0.5200	35.460	35.470
149	0.5190	0.5190	35.460	35.470
150	0.5200	0.5200	35.470	35.460
151	0.5190	0.5200	35.460	35.470

TABLE F11 (continued)

152	0.5200	0.5200	35.460	35.460
153	0.5200	0.5200	35.460	35.460
154	0.5200	0.5200	35.470	35.460
155	0.5200	0.5200	35.460	35.460
156	0.5200	0.5200	35.480	35.460
157	0.5190	0.5180	35.490	35.460
158	0.5180	0.5180	35.490	35.490
159	0.5170	0.5170	35.490	35.490
160	0.5190	0.5190	35.490	35.500
161	0.5180	0.5190	35.490	35.460
162	0.5190	0.5190	35.490	35.490
163	0.5170	0.5180	35.490	35.490
164	0.5180	0.5170	35.500	35.490
165	0.5170	0.5180	35.490	35.490
166	0.5170	0.5170	35.480	35.460
167	0.5170	0.5170	35.480	35.500
168	0.5180	0.5170	35.490	35.470
169	0.5170	0.5190	35.480	35.480
170	0.5180	0.5180	35.500	35.500
171	0.5170	0.5170	35.500	35.500
172	0.2480	0.2470	17.000	17.010
173	0.2470	0.2480	17.010	17.010
174	0.2470	0.2470	17.000	17.000
175	0.2470	0.2470	17.000	17.000
176	0.2470	0.2480	17.000	17.000
177	0.2470	0.2480	17.010	17.010
178	0.2480	0.2470	17.000	17.000
179	0.2470	0.2480	17.000	17.000
180	0.2480	0.2480	17.010	17.000
181	0.2470	0.2470	17.010	17.010
182	0.2480	0.2480	17.010	17.010
183	0.2480	0.2470	17.010	17.010
184	0.2480	0.2480	17.010	17.010
185	0.6490	0.6490	44.620	44.620
186	0.6490	0.6490	44.630	44.630
187	0.6490	0.6480	44.630	44.630
188	0.6500	0.6490	44.620	44.620
189	0.6490	0.6490	44.610	44.610

TABLE F11 (continued)

190	0.6520	0.6520	44.640	44.640
191	0.6510	0.6520	44.650	44.640
192	0.6520	0.6510	44.620	44.630
193	0.6510	0.6510	44.610	44.620
194	0.6510	0.6500	44.620	44.620
195	0.6510	0.6510	44.630	44.640
196	0.6500	0.6500	44.620	44.620
197	0.6500	0.6510	44.620	44.620
198	0.5190	0.5190	35.470	35.470
199	0.5190	0.5190	35.470	35.470
200	0.5190	0.5190	35.470	35.460
201	0.5190	0.5190	35.470	35.460
202	0.5190	0.5190	35.460	35.450
203	0.5190	0.5190	35.440	35.450
204	0.5190	0.5190	35.450	35.450
205	0.5190	0.5190	35.450	35.450
206	0.5190	0.5190	35.460	35.460
207	0.5190	0.5200	35.460	35.460
208	0.5190	0.5290	35.470	35.470
209	0.5190	0.5290	35.460	35.470
210	0.5190	0.5290	35.460	35.470
211	0.5200	0.5210	35.560	35.570
212	0.5210	0.5200	35.570	35.560
213	0.5200	0.5210	35.550	35.550
214	0.5200	0.5200	35.550	35.560
215	0.5200	0.5200	35.560	35.550
216	0.5190	0.5190	35.550	35.550
217	0.5190	0.5190	35.560	35.560
218	0.5190	0.5190	35.560	35.560
219	0.5190	0.5190	35.570	35.570
220	0.5190	0.5190	35.570	35.570
221	0.5190	0.5200	35.580	35.580
222	0.5200	0.5190	35.570	35.580
223	0.5190	0.5190	35.560	35.560
224	0.5170	0.5170	35.450	35.450
225	0.5170	0.5170	35.450	35.460
226	0.5170	0.5170	35.440	35.440
227	0.5170	0.5170	35.450	35.440
228	0.5170	0.5170	35.450	35.450

TABLE F11 (continued)

229	0.5160	0.5170	35.410	35.420
230	0.5170	0.5170	35.420	35.430
231	0.5170	0.5170	35.430	35.440
232	0.5170	0.5170	35.450	35.450
233	0.5170	0.5170	35.460	35.460
234	0.5170	0.5170	35.460	35.460
235	0.5170	0.5170	35.460	35.460
236	0.5170	0.5170	35.470	35.470
237	0.5180	0.5180	35.460	35.450
238	0.5180	0.5180	35.460	35.460
239	0.5170	0.5170	35.460	35.470
240	0.5180	0.5180	35.470	35.470
241	0.5180	0.5190	35.470	35.480
242	0.5180	0.5180	35.480	35.480
243	0.5180	0.5180	35.460	35.460
244	0.5180	0.5180	35.470	35.460
245	0.5180	0.5180	35.460	35.470
246	0.5180	0.5180	35.460	35.470
247	0.5180	0.5180	35.460	35.470
248	0.5180	0.5180	35.470	35.470
249	0.5180	0.5180	35.470	35.470
250	0.2480	0.2480	17.010	17.010
251	0.2480	0.2480	17.010	17.010
252	0.2480	0.2480	17.010	17.010
253	0.2490	0.2480	17.010	17.010
254	0.2490	0.2480	17.010	17.010
255	0.2480	0.2480	17.010	17.010
256	0.2480	0.2480	17.010	17.010
257	0.2490	0.2490	17.010	17.010
258	0.2490	0.2480	17.010	17.010
259	0.2480	0.2480	17.010	17.010
260	0.2480	0.2480	17.010	17.010
261	0.2480	0.2480	17.010	17.010
262	0.2480	0.2490	17.010	17.010
263	0.6530	0.6530	44.620	44.630
264	0.6530	0.6530	44.620	44.620
265	0.6540	0.6530	44.640	44.630
266	0.6530	0.6530	44.630	44.640

TABLE F11 (continued)

267	0.6530	0.6530	44.640	44.640
268	0.6530	0.6530	44.630	44.640
269	0.6530	0.6530	44.610	44.620
270	0.6530	0.6530	44.620	44.620
271	0.6530	0.6530	44.620	44.620
272	0.6530	0.6530	44.620	44.630
273	0.6530	0.6530	44.630	44.630
274	0.6530	0.6530	44.610	44.610
275	0.6520	0.6530	44.610	44.620
276	0.5190	0.5190	35.480	35.480
277	0.5190	0.5190	35.480	35.490
278	0.5190	0.5190	35.500	35.500
279	0.5190	0.5200	35.510	35.510
280	0.5190	0.5190	35.510	35.500
281	0.5190	0.5190	35.510	35.510
282	0.5190	0.5200	35.500	35.500
283	0.5190	0.5190	35.460	35.460
284	0.5190	0.5190	35.490	35.480
285	0.5190	0.5190	35.480	35.480
286	0.5190	0.5200	35.490	35.500
287	0.5190	0.5190	35.500	35.510
288	0.5190	0.5200	35.500	35.500
289	0.5170	0.5170	35.400	35.410
290	0.5170	0.5170	35.410	35.410
291	0.5170	0.5170	35.420	35.420
292	0.5170	0.5170	35.420	35.420
293	0.5140	0.5130	35.380	35.390
294	0.5150	0.5150	35.390	35.400
295	0.5150	0.5150	35.400	35.410
296	0.5150	0.5150	35.400	35.400
297	0.5150	0.5140	35.400	35.410
298	0.5140	0.5140	35.380	35.380
299	0.5140	0.5140	35.390	35.390
300	0.5140	0.5140	35.390	35.390
301	0.5140	0.5140	35.400	35.400
302	0.5140	0.5140	35.430	35.440
303	0.5150	0.5150	35.440	35.440
304	0.5150	0.5150	35.430	35.420
305	0.5150	0.5150	35.430	35.430

TABLE F11 (continued)

306	0.5150	0.5150	35.430	35.430
307	0.5140	0.5140	35.400	35.400
308	0.5140	0.5140	35.400	35.400
309	0.5140	0.5140	35.410	35.410
310	0.5140	0.5140	35.420	35.420
311	0.5140	0.5140	35.430	35.440
312	0.5140	0.5140	35.430	35.410
313	0.5140	0.5140	35.430	35.410
314	0.5140	0.5140	35.430	35.420
315	0.5170	0.5170	35.420	35.420
316	0.5160	0.5160	35.410	35.410
317	0.5160	0.5160	35.410	35.420
318	0.5160	0.5170	35.410	35.420
319	0.5170	0.5170	35.410	35.400
320	0.5170	0.5160	35.400	35.410
321	0.5160	0.5160	35.420	35.430
322	0.5170	0.5170	35.430	35.440
323	0.5170	0.5160	35.420	35.430
324	0.5160	0.5160	35.420	35.400
325	0.5170	0.5170	35.430	35.420
326	0.5170	0.5170	35.450	35.450
327	0.5180	0.5180	35.450	35.450
328	0.2480	0.2480	17.010	17.020
329	0.2480	0.2480	17.010	17.020
330	0.2480	0.2480	17.020	17.020
331	0.2480	0.2480	17.020	17.020
332	0.2480	0.2460	17.020	17.020
333	0.2480	0.2480	17.020	17.030
334	0.2480	0.2480	17.020	17.020
335	0.2480	0.2460	17.020	17.020
336	0.2480	0.2480	17.020	17.030
337	0.2480	0.2480	17.030	17.030
338	0.2480	0.2460	17.030	17.020
339	0.2480	0.2460	17.030	17.030
340	0.2480	0.2480	17.030	17.030
341	0.6510	0.6520	44.600	44.600
342	0.6520	0.6520	44.600	44.600
343	0.6520	0.6520	44.590	44.600

TABLE F11 (continued)

344	0.6510	0.6510	44.600	44.590
345	0.6520	0.6510	44.580	44.560
346	0.6510	0.6520	44.600	44.600
347	0.6520	0.6510	44.590	44.610
348	0.6530	0.6520	44.610	44.610
349	0.6520	0.6520	44.620	44.610
350	0.6520	0.6520	44.600	44.590
351	0.6520	0.6520	44.590	44.600
352	0.6520	0.6520	44.600	44.600
353	0.6520	0.6520	44.600	44.600
354	0.5170	0.5170	35.430	35.430
355	0.5180	0.5170	35.440	35.440
356	0.5170	0.5180	35.450	35.460
357	0.5180	0.5170	35.460	35.450
358	0.5170	0.5170	35.460	35.460
359	0.5170	0.5170	35.450	35.460
360	0.5170	0.5170	35.460	35.460
361	0.5160	0.5160	35.450	35.450
362	0.5170	0.5170	35.450	35.460
363	0.5170	0.5160	35.460	35.460
364	0.5170	0.5160	35.420	35.420
365	0.5160	0.5160	35.430	35.430
366	0.5160	0.5160	35.440	35.440
367	0.5160	0.5160	35.410	35.400
368	0.5160	0.5160	35.400	35.400
369	0.5160	0.5160	35.400	35.400
370	0.5160	0.5160	35.400	35.400
371	0.5160	0.5160	35.400	35.400
372	0.5160	0.5160	35.410	35.410
373	0.5160	0.5140	35.410	35.410
374	0.5150	0.5150	35.410	35.410
375	0.5150	0.5160	35.410	35.410
376	0.5150	0.5140	35.400	35.390
377	0.5150	0.5150	35.400	35.400
378	0.5160	0.5160	35.390	35.410
379	0.5160	0.5150	35.420	35.420
380	0.5150	0.5140	35.420	35.410
381	0.5140	0.5130	35.420	35.410
382	0.5140	0.5140	35.420	35.410

TABLE F11 (continued)

383	0.5150	0.5140	35.420	35.410
384	0.5130	0.5140	35.410	35.410
385	0.5140	0.5140	35.410	35.410
386	0.5140	0.5140	35.410	35.410
387	0.5140	0.5140	35.420	35.410
388	0.5140	0.5140	35.420	35.410
389	0.5140	0.5150	35.410	35.430
390	0.5140	0.5150	35.430	35.430
391	0.5140	0.5140	35.430	35.430
392	0.5140	0.5130	35.430	35.420
393	0.5180	0.5180	35.460	35.460
394	0.5190	0.5190	35.470	35.460
395	0.5190	0.5190	35.460	35.470
396	0.5180	0.5180	35.460	35.450
397	0.5180	0.5180	35.450	35.450
398	0.5180	0.5190	35.450	35.450
399	0.5180	0.5180	35.450	35.460
400	0.5180	0.5190	35.450	35.450
401	0.5180	0.5180	35.450	35.460
402	0.5180	0.5180	35.460	35.460
403	0.5190	0.5190	35.480	35.470
404	0.5190	0.5190	35.470	35.480
405	0.5180	0.5190	35.470	35.470
406	0.6520	0.6520	44.610	44.600
407	0.6510	0.6520	44.600	44.590
408	0.6530	0.6520	44.600	44.590
409	0.6520	0.6520	44.600	44.600
410	0.6520	0.6520	44.590	44.500
411	0.6520	0.6510	44.580	44.560
412	0.6520	0.6520	44.580	44.580
413	0.6530	0.6520	44.580	44.590
414	0.6520	0.6520	44.580	44.560
415	0.6530	0.6530	44.580	44.590
416	0.6520	0.6520	44.590	44.600
417	0.6520	0.6520	44.600	44.610
418	0.6520	0.6520	44.610	44.620
419	0.2460	0.2460	17.020	17.030
420	0.2450	0.2460	17.020	17.020

TABLE F11 (continued)

421	0.2460	0.2450	17.020	17.030
422	0.2450	0.2450	17.030	17.030
423	0.2450	0.2450	17.030	17.030
424	0.2450	0.2450	17.020	17.020
425	0.2450	0.2440	17.020	17.020
426	0.2450	0.2440	17.020	17.020
427	0.2440	0.2440	17.020	17.020
428	0.2450	0.2450	17.030	17.040
429	0.2450	0.2440	17.030	17.040
430	0.2440	0.2450	17.030	17.030
431	0.2440	0.2450	17.030	17.030
432	0.5150	0.5150	35.430	35.430
433	0.5150	0.5150	35.440	35.430
434	0.5150	0.5150	35.440	35.440
435	0.5150	0.5150	35.440	35.440
436	0.5150	0.5150	35.440	35.430
437	0.5150	0.5150	35.430	35.430
438	0.5150	0.5150	35.430	35.430
439	0.5150	0.5150	35.430	35.430
440	0.5150	0.5150	35.440	35.440
441	0.5150	0.5150	35.440	35.440
442	0.5150	0.5150	35.440	35.440
443	0.5140	0.5140	35.440	35.440
444	0.5170	0.5170	35.440	35.440
445	0.5160	0.5160	35.400	35.410
446	0.5150	0.5160	35.410	35.410
447	0.5150	0.5150	35.400	35.400
448	0.5160	0.5160	35.410	35.400
449	0.5150	0.5150	35.410	35.400
450	0.5150	0.5160	35.400	35.400
451	0.5160	0.5150	35.400	35.400
452	0.5150	0.5150	35.400	35.410
453	0.5150	0.5150	35.400	35.400
454	0.5150	0.5150	35.390	35.390
455	0.5150	0.5150	35.400	35.400
456	0.5150	0.5150	35.400	35.400
457	0.5150	0.5150	35.400	35.400
458	0.7270	0.7270	49.600	49.600
459	0.7270	0.7240	49.600	49.600

TABLE F11 (continued)

460	0.7240	0.7250	49.600	49.610
461	0.7270	0.7270	49.610	49.620
462	0.7250	0.7280	49.630	49.630
463	0.7280	0.7270	49.640	49.640
464	0.7280	0.7280	49.650	49.650
465	0.7280	0.7260	49.630	49.630
466	0.7280	0.7280	49.630	49.630
467	0.7280	0.7280	49.630	49.630
468	0.7270	0.7260	49.630	49.630
469	0.7280	0.7240	49.630	49.630
470	0.7270	0.7270	49.630	49.620
471	0.7270	0.7270	49.700	49.680
472	0.7280	0.7270	49.690	49.690
473	0.7270	0.7260	49.680	49.650
474	0.7260	0.7260	49.670	49.660
475	0.7250	0.7260	49.630	49.670
476	0.7260	0.7260	49.670	49.680
477	0.7260	0.7260	49.690	49.670
478	0.7260	0.7260	49.670	49.660
479	0.7260	0.7260	49.680	49.680
480	0.7260	0.7260	49.640	49.650
481	0.7260	0.7250	49.640	49.650
482	0.7250	0.7260	49.650	49.660
483	0.7260	0.7260	49.650	49.650
484	0.7240	0.7240	49.670	49.660
485	0.7230	0.7230	49.670	49.670
486	0.7230	0.7230	49.680	49.660
487	0.7230	0.7220	49.680	49.680
488	0.7220	0.7230	49.660	49.650
489	0.7230	0.7240	49.670	49.660
490	0.7230	0.7240	49.670	49.660
491	0.7230	0.7240	49.650	49.670
492	0.7230	0.7240	49.650	49.660
493	0.7220	0.7220	49.670	49.660
494	0.7230	0.7230	49.670	49.670
495	0.7240	0.7230	49.670	49.690
496	0.7220	0.7220	49.660	49.660
497	0.5140	0.5130	35.400	35.390

TABLE F11 (continued)

498	0.5140	0.5130	35.390	35.390
499	0.5130	0.5130	35.380	35.390
500	0.5150	0.5150	35.400	35.390
501	0.5150	0.5150	35.400	35.410
502	0.5150	0.5150	35.400	35.390
503	0.5150	0.5140	35.400	35.400
504	0.5140	0.5140	35.390	35.390
505	0.5150	0.5150	35.400	35.410
506	0.5140	0.5140	35.400	35.400
507	0.5140	0.5140	35.390	35.400
508	0.5140	0.5140	35.390	35.390
509	0.5140	0.5140	35.390	35.390
510	0.7260	0.72[illegible]0	49.670	49.600
511	0.7260	0.7260	49.660	49.600
512	0.7260	0.7250	49.670	49.650
513	0.7250	0.7260	49.660	49.670
514	0.7250	0.7260	49.650	49.600
515	0.7250	0.7260	49.650	49.600
516	0.7260	0.7250	49.650	49.650
517	0.7250	0.7250	49.650	49.640
518	0.7260	0.7260	49.640	49.640
519	0.7250	0.7250	49.650	49.650
520	0.7250	0.7260	49.650	49.650
521	0.7250	0.7260	49.650	49.650
522	0.7260	0.7260	49.650	49.650
523	0.7240	0.7240	49.580	49.590
524	0.7250	0.7230	49.590	49.590
525	0.7230	0.7230	49.600	49.600
526	0.7240	0.7230	49.590	49.580
527	0.7220	0.7230	49.580	49.590
528	0.7230	0.7220	49.590	49.560
529	0.7240	0.7240	49.570	49.560
530	0.7240	0.7240	49.570	49.550
531	0.7240	0.7250	49.590	49.590
532	0.7250	0.7240	49.620	49.600
533	0.7240	0.7240	49.600	49.590
534	0.7240	0.7240	49.600	49.590
535	0.7240	0.7240	49.590	49.600
536	0.7230	0.7240	49.660	49.640

TABLE F11 (continued)

537	0.7230	0.7230	49.640	49.630
538	0.7230	0.7230	49.630	49.630
539	0.7230	0.7220	49.630	49.630
540	0.7220	0.7230	49.620	49.630
541	0.7230	0.7230	49.640	49.640
542	0.7230	0.7230	49.650	49.650
543	0.7240	0.7240	49.650	49.650
544	1.9660	1.9660	132.600	132.500
545	1.9660	1.9670	132.500	132.600
546	1.9670	1.9680	132.600	132.600
547	1.9680	1.9680	132.600	132.600
548	1.9700	1.9690	132.700	132.700
549	0.5180	0.5160	35.400	35.400
550	0.5180	0.5180	35.400	35.400
551	0.5180	0.5180	35.400	35.400
552	0.5180	0.5160	35.410	35.400
553	0.5180	0.5180	35.410	35.410
554	0.5180	0.5180	35.410	35.410
555	0.5170	0.5160	35.410	35.410
556	0.6540	0.6540	44.580	44.590
557	0.6540	0.6540	44.590	44.590
558	0.6530	0.6530	44.590	44.600
559	0.6540	0.6540	44.610	44.600
560	0.6530	0.6530	44.610	44.600
561	0.6530	0.6520	44.610	44.590
562	0.6540	0.6540	44.610	44.590
563	0.5170	0.5170	35.430	35.430
564	0.5170	0.5170	35.430	35.430
565	0.5170	0.5170	35.430	35.430
566	0.5170	0.5170	35.440	35.440
567	0.5170	0.5170	35.430	35.440
568	0.8080	0.8080	54.920	54.950
569	0.8080	0.8080	54.950	54.950
570	0.8080	0.8090	54.990	55.000
571	0.8090	0.8090	54.970	55.010
572	0.8090	0.8110	55.040	55.050
573	0.8100	0.8100	55.070	55.100
574	0.8090	0.8110	55.080	55.080

TABLE F11 (continued)

575	0.8110	0.8110	55.070	55.100
576	0.9420	0.9430	63.800	63.820
577	0.9420	0.9430	63.810	63.810
578	0.9420	0.9420	63.780	63.780
579	0.9420	0.9420	63.800	63.790
580	0.9430	0.9430	63.830	63.830
581	0.9440	0.9430	63.870	63.890
582	0.9440	0.9440	63.860	63.870
583	0.9440	0.9440	63.860	63.860
584	0.9390	0.9390	64.000	64.000
585	0.9410	0.9420	64.050	64.080
586	0.9340	0.9350	64.080	64.090
587	0.9420	0.9420	64.100	64.100
588	0.9360	0.9370	64.090	64.090
589	1.3220	1.3220	90.080	90.060
590	1.3220	1.3230	90.070	90.110
591	1.3210	1.3210	90.120	90.090
592	1.3190	1.3200	90.080	90.060
593	1.3200	1.3200	90.110	90.120
594	1.3240	1.3250	90.090	90.090
595	1.7820	1.7800	120.380	120.350
596	1.7810	1.7810	120.300	120.380
597	1.7820	1.7810	120.420	120.360
598	1.7820	1.7800	120.370	120.340
599	1.1690	1.1680	79.240	79.240
600	1.1680	1.1670	79.240	79.170
601	1.1680	1.1680	79.180	79.180
602	1.1680	1.1660	79.200	79.210
603	1.1680	1.1670	79.190	79.210
604	1.1670	1.1680	79.200	79.200
605	0.9530	0.9520	64.610	64.580
606	0.9520	0.9520	64.560	64.580
607	0.9530	0.9520	64.550	64.560
608	0.9520	0.9520	64.550	64.560
609	0.9520	0.9520	64.560	64.570
610	0.9520	0.9520	64.570	64.540
611	1.1660	1.1680	79.040	79.010
612	1.1680	1.1670	79.020	79.020
613	1.1680	1.1670	79.030	79.030

TABLE F11 (continued)

614	1.1670	1.1670	79.020	79.020
615	1.1670	1.1670	79.000	78.970
616	1.1680	1.1680	78.990	79.060
617	1.3290	1.3290	89.880	89.840
618	1.3290	1.3280	89.870	89.890
619	1.3290	1.3300	89.900	89.940
620	1.3290	1.3290	89.970	89.990
621	1.3300	1.3300	89.960	89.950
622	1.3300	1.3310	89.950	90.000
623	1.7860	1.7890	120.560	120.670
624	1.7920	1.7920	120.860	120.830
625	1.7900	1.7890	120.760	120.770
626	1.7910	1.7910	120.800	120.800
627	1.7890	1.7890	120.720	120.770
628	1.7890	1.7900	120.780	120.790
629	1.0430	1.0440	70.730	70.740
630	1.0440	1.0450	70.740	70.740
631	1.0430	1.0430	70.720	70.760
632	1.0450	1.0450	70.750	70.750
633	1.0450	1.0440	70.740	70.740
634	1.0430	1.0460	70.780	70.780
635	0.9370	0.9360	63.640	63.560
636	0.9360	0.9360	63.560	63.520
637	0.9360	0.9360	63.490	63.480
638	0.9370	0.9370	63.520	63.540
639	0.9360	0.9360	63.520	63.540
640	0.9360	0.9370	63.520	63.520
641	1.0380	1.0380	70.500	70.460
642	1.0380	1.0370	70.480	70.450
643	1.0370	1.0380	70.440	70.430
644	1.0370	1.0370	70.420	70.410
645	1.0360	1.0370	70.410	70.400
646	1.0370	1.0380	70.400	70.380
647	1.1790	1.1790	80.010	79.990
648	1.1790	1.1790	79.990	79.960
649	1.1790	1.1790	79.980	80.000
650	1.1790	1.1790	79.980	79.970
651	1.1780	1.1790	79.990	79.960

TABLE F11 (continued)

652	1.1790	1.1790	79.990	80.000
653	1.3270	1.3260	89.960	89.830
654	1.3260	1.3260	89.840	89.810
655	1.3260	1.3270	89.810	89.830
656	1.3260	1.3260	89.820	89.810
657	1.3260	1.3250	89.800	89.800
658	1.3260	1.3270	89.800	89.800
659	1.7800	1.7810	120.600	120.580
660	1.7810	1.7820	120.580	120.560
661	1.7810	1.7810	120.520	120.560
662	1.7810	1.7800	120.530	120.540
663	1.7810	1.7820	120.560	120.560
664	1.7810	1.7830	120.560	120.650
665	0.5170	0.5140	35.470	35.470
666	0.5140	0.5140	35.470	35.470
667	0.5140	0.5150	35.480	35.470
668	0.5160	0.5150	35.480	35.480
669	0.5140	0.5140	35.460	35.460
670	0.6470	0.6470	44.500	44.510
671	0.6470	0.6480	44.520	44.520
672	0.6480	0.6480	44.530	44.520
673	0.6480	0.6480	44.510	44.510
674	0.6480	0.6480	44.510	44.510
675	0.9420	0.9420	64.390	64.420
676	0.9420	0.9420	64.440	64.450
677	0.9430	0.9430	64.480	64.500
678	0.9420	0.9430	64.500	64.490
679	0.5140	0.5130	35.400	35.400
680	0.5130	0.5140	35.400	35.400
681	0.5140	0.5130	35.400	35.410
682	0.5140	0.5140	35.400	35.410
683	0.5130	0.5140	35.410	35.410
684	0.5140	0.5140	35.410	35.420
685	0.6520	0.6520	44.530	44.540
686	0.6520	0.6530	44.540	44.550
687	0.6520	0.6520	44.550	44.550
688	0.6520	0.6530	44.560	44.560
689	0.6520	0.6530	44.570	44.570
690	0.6520	0.6530	44.550	44.570

TABLE F11 (continued)

691	0.7980	0.7980	54.480	54.470
692	0.7980	0.7980	54.460	54.460
693	0.7980	0.7990	54.430	54.470
694	0.7980	0.7990	54.430	54.460
695	0.7980	0.7980	54.420	54.420
696	0.7980	0.7980	54.460	54.450
697	0.9450	0.9450	64.320	64.310
698	0.9450	0.9450	64.310	64.300
699	0.9450	0.9450	64.330	64.310
700	0.9450	0.9450	64.320	64.310
701	0.9450	0.9450	64.310	64.320
702	0.9420	0.9450	64.250	64.310
703	0.5140	0.5150	35.410	35.420
704	0.5140	0.5140	35.420	35.410
705	0.5140	0.5140	35.410	35.400
706	0.5150	0.5140	35.410	35.410
707	0.5150	0.5140	35.400	35.400
708	0.5140	0.5140	35.400	35.400
709	0.6480	0.6480	44.540	44.550
710	0.6480	0.6480	44.550	44.550
711	0.6490	0.6490	44.550	44.560
712	0.6480	0.6490	44.560	44.570
713	0.6480	0.6480	44.570	44.560
714	0.6490	0.6480	44.570	44.560
715	0.8220	0.8220	56.270	56.260
716	0.8220	0.8210	56.270	56.260
717	0.8210	0.8210	56.250	56.250
718	0.8220	0.8200	56.260	56.210
719	0.8220	0.8210	56.200	56.230
720	0.8210	0.8210	56.230	56.220
721	0.5180	0.5180	35.400	35.410
722	0.5180	0.5180	35.410	35.420
723	0.5180	0.5180	35.420	35.420
724	0.5180	0.5160	35.420	35.420
725	0.5180	0.5160	35.430	35.430
726	0.5180	0.5180	35.440	35.430
727	0.6510	0.6510	44.510	44.520
728	0.6510	0.6520	44.520	44.530

TABLE F11 (continued)

729	0.6520	0.6520	44.530	44.540
730	0.6520	0.6520	44.540	44.540
731	0.6520	0.6520	44.540	44.550
732	0.6520	0.6510	44.550	44.560
733	0.8160	0.8160	55.870	55.860
734	0.8170	0.8170	55.840	55.830
735	0.8170	0.8170	55.810	55.810
736	0.8170	0.8160	55.810	55.820
737	0.8170	0.8180	55.820	55.820
738	0.8180	0.8170	55.840	55.840

TABLE F12

THE WATTS CALCULATED FOR TOP AND BOTTOM PLATES ARE

1	2.2973	2	2.2995	3	2.3000	4	2.3001	5	2.2997	6	2.2986		2.2980
8	2.2970	9	2.2970	10	2.2962	11	2.2961	12	2.2965	13	2.2936	14	2.2928
15	2.2927	16	2.2971	17	2.2967	18	2.2941	19	2.2941	20	2.2927	21	2.2920
22	2.2930	23	2.2935	24	2.2927	25	2.2905	26	2.2900	27	2.2903	28	2.2905
29	0.5251	30	0.5257	31	0.5262	32	0.5269	33	0.5274	34	0.5311	35	0.5249
36	0.5227	37	0.5207	38	0.5297	39	0.5279	40	0.5238	41	0.5262	42	0.5260
43	3.6530	44	3.6505	45	3.6515	46	3.6498	47	3.6501	48	3.6479	49	3.6476
50	3.6551	51	3.6552	52	3.6515	53	3.6475	54	3.6462	55	3.6469	56	2.3107
57	2.3101	58	2.3092	59	2.3056	60	2.3058	61	2.3173	62	2.3195	63	2.3166
64	2.3189	65	2.3166	66	2.3122	67	2.3138	68	2.3125	69	2.3045	70	2.3030
71	2.3039	72	2.3087	73	2.3043	74	2.3011	75	2.3017	76	2.3046	77	2.3049
78	2.2982	79	2.3014	80	2.3043	81	2.2849	82	2.2857	83	2.2852	84	2.2846
85	2.2859	86	2.2862	87	2.2859	88	2.2833	89	2.2852	90	2.2824	91	2.2862
92	2.2933	93	2.2938	94	0.5236	95	0.5262	96	0.5266	97	0.5197	98	0.5190
99	0.5190	100	0.5202	101	0.5187	102	0.5241	103	0.5254	104	0.5255	105	0.5244
106	0.5255	107	3.6325	108	3.6321	109	3.6253	110	3.6329	111	3.6293	112	3.6253
113	3.6265	114	3.6261	115	3.6229	116	3.6209	117	3.6277	118	3.6242	119	3.6293
120	2.2846	121	2.2843	122	2.2840	123	2.2868	124	2.2837	125	2.2837	126	2.2856
127	2.2811	128	2.2833	129	2.2840	130	2.2846	131	2.2843	132	2.2837	133	2.3004
134	2.2900	135	2.3004	136	2.3039	137	2.3004	138	2.2972	139	2.2972	140	2.2794
141	2.2824	142	2.2795	143	2.2845	144	2.2864	145	2.2839	146	2.3166	147	2.3033
148	2.3052	149	2.3008	150	2.3052	151	2.3030	152	2.3049	153	2.3049	154	2.3059
155	2.3049	156	2.3062	157	2.2979	158	2.2980	159	2.2935	160	2.3027	161	2.2999
162	2.3024	163	2.2958	164	2.2961	165	2.2958	166	2.2929	167	2.2935	168	2.2951
169	2.2973	170	2.2986	171	2.2942	172	0.5261	173	0.5262	174	0.5249	175	0.5249
176	0.5259	177	0.5262	178	0.5259	179	0.5259	180	0.5272	181	0.5252	182	0.5273
183	0.5262	184	0.5273	185	3.6198	186	3.6206	187	3.6176	188	3.6226	189	3.6190
190	3.6382	191	3.6358	192	3.6341	193	3.6365	194	3.6282	195	3.6322	196	3.6254
197	3.6282	198	2.3011	199	2.3011	200	2.3008	201	2.3006	202	2.3001	203	2.2995
204	2.2998	205	2.2998	206	2.3095	207	2.3027	208	2.3233	209	2.3230	210	2.3230
211	2.3139	212	2.3139	213	2.3130	214	2.3111	215	2.3111	216	2.3063	217	2.3070
218	2.3070	219	2.3076	220	2.3076	221	2.3105	222	2.3102	223	2.3070	224	2.2910
225	2.2913	226	2.2903	227	2.2906	228	2.2910	229	2.2885	230	2.2893	231	2.2900
232	2.2910	233	2.2916	234	2.2916	235	2.2916	236	2.2922	237	2.2957	238	2.2900
239	2.2919	240	2.2967	241	2.2992	242	2.2973	243	2.2960	244	2.2964	245	2.2904
246	2.2964	247	2.2964	248	2.2967	249	2.2967	250	0.5273	251	0.5273	252	0.5273
253	0.5284	254	0.5284	255	0.5273	256	0.5273	257	0.5294	258	0.5284	259	0.5273
260	0.5273	261	0.5273	262	0.5284	263	3.6445	264	3.6421	265	3.6451	266	3.6433
267	3.6437	268	3.6433	269	3.6417	270	3.6421	271	3.6421	272	3.6425	273	3.6429
274	3.6413	275	3.6389	276	2.3016	277	2.3021	278	2.3031	279	2.3059	280	2.3034
281	2.3037	282	2.3053	283	2.3018	284	2.3021	285	2.3016	286	2.3050	287	2.3034
288	2.3053	289	2.2880	290	2.2884	291	2.2890	292	2.2890	293	2.2713	294	2.2706
295	2.2792	296	2.2789	297	2.2770	298	2.2732	299	2.2738	300	2.2738	301	2.2745
302	2.2767	303	2.2814	304	2.2805	305	2.2808	306	2.2808	307	2.2745	308	2.2745
309	2.2751	310	2.2757	311	2.2767	312	2.2757	313	2.2757	314	2.2761	315	2.2890
316	2.2839	317	2.2843	318	2.2855	319	2.2860	320	2.2858	321	2.2649	322	2.2900
323	2.2871	324	2.2839	325	2.2893	326	2.2910	327	2.2954	328	0.5275	329	0.5275
330	0.5276	331	0.5276	332	0.5276	333	0.5278	334	0.5276	335	0.5276	336	0.5278
337	0.5279	338	0.5278	339	0.5279	340	0.5279	341	3.6321	342	3.6349	343	3.6345
344	3.6289	345	3.6305	346	3.6321	347	3.6321	348	3.6385	349	3.6361	350	3.6345
351	3.6345	352	3.6349	353	3.6349	354	2.2597	355	2.2925	356	2.2935	357	2.2935
358	2.2916	359	2.2913	360	2.2916	361	2.2865	362	2.2913	363	2.2894	364	2.2808
365	2.2852	366	2.2859	367	2.2836	368	2.2833	369	2.2833	370	2.2833	371	2.2833
372	2.2839	373	2.2795	374	2.2795	375	2.2817	376	2.2763	377	2.2769	378	2.2833
379	2.2824	380	2.2776	381	2.2732	382	2.2754	383	2.2776	384	2.2729	385	2.2751
386	2.2751	387	2.2754	388	2.2754	389	2.2779	390	2.2766	391	2.2764	392	2.2738
393	2.2960	394	2.3008	395	2.3008	396	2.2957	397	2.2954	398	2.2976	399	2.2957
400	2.2976	401	2.2957	402	2.2960	403	2.3014	404	2.3014	405	2.2959	406	3.6353
407	3.6317	408	3.6373	409	3.6349	410	3.6337	411	3.6305	412	3.6333	413	3.6365
414	3.6333	415	3.6393	416	3.6345	417	3.6353	418	3.6361	419	0.5235	420	0.5223
421	0.5225	422	0.5215	423	0.5215	424	0.5212	425	0.5202	426	0.5202	427	0.5191
428	0.5217	429	0.5206	430	0.5205	431	0.5205	432	2.2808	433	2.2811	434	2.2814
435	2.2814	436	2.2811	437	2.2838	438	2.2808	439	2.2808	440	2.2814	441	2.2814
442	2.2814	443	2.2770	444	2.2903	445	2.2836	446	2.2817	447	2.2769	448	2.2836
449	2.2792	450	2.2811	451	2.2811	452	2.2792	453	2.2789	454	2.2782	455	2.2704
456	2.2789	457	2.2789	458	4.5074	459	4.4901	460	4.4924	461	4.5000	462	4.5070
463	4.5141	464	4.5182	465	4.5163	466	4.5163	467	4.5163	468	4.5132	469	4.5039
470	4.5097	471	4.5156	472	4.5137	473	4.5102	474	4.5071	475	4.5026	476	4.5000
477	4.5085	478	4.5071	479	4.5035	480	4.5053	481	4.5022	482	4.5031	483	4.5057
484	4.4956	485	4.4889	486	4.4839	487	4.4867	488	4.4845	489	4.4910	490	4.4925
491	4.4911	492	4.4907	493	4.4832	494	4.4809	495	4.4929	496	4.4910	497	2.2719
498	2.2716	499	2.2691	500	2.2736	501	2.2792	502	2.2786	503	2.2767	504	2.2738
505	2.2792	506	2.2745	507	2.2741	508	2.2738	509	2.2738	510	4.5071	511	4.5066
512	4.5035	513	4.5040	514	4.5031	515	4.5031	516	4.5026	517	4.4991	518	4.5048
519	4.4995	520	4.5026	521	4.5020	522	4.5057	523	4.4874	524	4.4879	525	4.4826
526	4.4843	527	4.4701	528	4.4772	529	4.4856	530	4.4652	531	4.4910	532	4.4968
533	4.4883	534	4.4883	535	4.4883	536	4.4902	537	4.4658	538	4.4653	539	4.4022
540	4.4318	541	4.4862	542	4.4871	543	4.4933	544	32.5742	545	32.5824	546	32.6113
547	32.6196	548	32.6691	549	2.2922	550	2.2922	551	2.2922	552	2.2925	553	2.2968
554	2.2928	555	2.2996	556	3.6448	557	3.6452	558	3.6401	559	3.6465	560	3.6409
561	3.6377	562	3.6461	563	2.2897	564	2.2697	565	2.2897	566	2.2903	567	2.2900
568	5.5484	569	5.5500	570	5.5579	571	5.5609	572	5.5733	573	5.5774	574	5.5760
575	5.5842	576	7.5176	577	7.5176	578	7.5101	579	7.5119	580	7.5240	581	7.5335
582	7.5361	583	7.5367	584	7.5120	585	7.5396	586	7.4859	587	7.5478	588	7.5025
589	14.8841	590	14.8730	591	14.8706	592	14.8559	593	14.8690	594	14.9155	595	26.7903
596	26.7907	597	26.8093	598	26.7940	599	11.5740	600	11.5590	601	11.5803	602	11.5839
603	11.5583	604	11.5583	605	7.6909	606	7.6658	607	7.6881	608	7.6820	609	7.6832
610	7.6820	611	11.5278	612	11.5320	613	11.5334	614	11.5270	615	11.5219	616	11.5391
617	14.9280	618	14.9257	619	14.9436	620	14.9479	621	14.9550	622	14.9640	623	26.9499
624	27.0693	625	27.0136	626	27.0441	627	27.0016	628	27.0181	629	9.2265	630	9.2300
631	9.2227	632	9.2417	633	9.2360	634	9.2412	635	7.4452	636	7.4342	637	7.4277
638	7.4410	639	7.4330	640	7.4358	641	9.1461	642	9.1364	643	9.1345	644	9.1275
645	9.1218	646	9.1287	647	11.7900	648	11.7878	649	11.7685	650	11.7863	651	11.7628
652	11.7893	653	14.9557	654	14.8885	655	14.8933	656	14.8868	657	14.8787	658	14.8900
659	26.8386	660	26.8494	661	25.8352	662	26.8266	663	26.8472	664	26.8648	665	2.2656
666	2.2789	667	2.2815	668	2.2862	669	2.2703	670	3.5993	671	3.6033	672	3.6065
673	3.6053	674	3.6053	675	7.5837	676	7.5864	677	7.6016	678	7.5933	679	2.2722
680	2.2722	681	2.2726	682	2.2748	683	2.2729	684	2.2754	685	3.6296	686	3.6332
687	3.6308	688	3.6344	689	3.6352	690	3.6344	691	5.4339	692	5.4324	693	5.4388
694	5.4343	695	5.4264	696	5.4319	697	7.5972	698	7.5960	699	7.5976	700	7.5972
701	7.5972	702	7.5810	703	2.2776	704	2.2754	705	2.2748	706	2.2773	707	2.2767
708	2.2745	709	3.6081	710	3.6086	711	3.6145	712	3.6126	713	3.6106	714	3.6125
715	5.7812	716	5.7777	717	5.7727	718	5.7711	719	5.7726	720	5.7701	721	2.2925
722	2.2931	723	2.2934	724	2.2934	725	2.2941	726	2.2944	727	3.6224	728	3.6260
729	3.6296	730	3.6300	731	3.6304	732	3.6264	733	5.6982	734	5.7021	735	5.6996
736	5.7036	737	5.7041	738	5.7001								

The Thermal Conductivities and Conductances ($W/M^{o}C$) - (Runs 1 to 738)

THE THERMAL CONDUCTIVITIES OF PERSPEX PIECES IN WATTS PER METRE PER DEGREE CELSIUS ARE

J	DTETOP	DTEBOT	THITOP	THIBOT	WATTAGE	CODCTO	CODCBO	AVTTOP	AVTBOT
1	1.683	1.750	.56896E-02	.55372E-02	2.297	0.1941	0.1809	50.19	50.16
2	1.662	1.775	.56896E-02	.55372E-02	2.299	0.1968	0.1792	50.26	50.23
3	1.696	1.776	.56896E-02	.55372E-02	2.301	0.1930	0.1793	50.31	50.28
4	1.691	1.776	.56896E-02	.55372E-02	2.300	0.1935	0.1793	50.36	50.33
5	1.688	1.794	.56896E-02	.55372E-02	2.300	0.1938	0.1774	50.38	50.36
6	1.680	1.790	.56896E-02	.55372E-02	2.299	0.1946	0.1777	50.40	50.37
7	1.680	1.794	.56896E-02	.55372E-02	2.299	0.1946	0.1774	50.40	50.37
8	1.733	1.794	.56896E-02	.55372E-02	2.297	0.1886	0.1773	50.53	50.55
9	1.690	1.797	.56896E-02	.55372E-02	2.297	0.1933	0.1770	50.44	50.42
10	1.682	1.803	.56896E-02	.55372E-02	2.298	0.1943	0.1764	50.43	50.42
11	1.685	1.806	.56896E-02	.55372E-02	2.298	0.1940	0.1762	50.47	50.43
12	1.703	1.789	.56896E-02	.55372E-02	2.297	0.1918	0.1777	50.46	50.46
13	1.685	1.802	.56896E-02	.55372E-02	2.294	0.1936	0.1762	50.48	50.45
14	1.706	1.808	.56896E-02	.55372E-02	2.293	0.1911	0.1755	50.48	50.47
15	1.648	1.814	.56642E-02	.56388E-02	2.293	0.1970	0.1782	50.43	50.35
16	1.656	1.843	.56642E-02	.56388E-02	2.297	0.1965	0.1757	50.44	50.37
17	1.658	1.829	.56642E-02	.56388E-02	2.297	0.1961	0.1770	50.44	50.39
18	1.656	1.835	.56642E-02	.56388E-02	2.294	0.1962	0.1763	50.46	50.39
19	1.658	1.830	.56642E-02	.56388E-02	2.294	0.1959	0.1767	50.46	50.40
20	1.661	1.816	.56642E-02	.56388E-02	2.293	0.1955	0.1780	50.43	50.38
21	1.664	1.822	.56642E-02	.56388E-02	2.292	0.1951	0.1773	50.44	50.38
22	1.648	1.829	.56642E-02	.56388E-02	2.293	0.1971	0.1767	50.48	50.39
23	1.629	1.813	.56642E-02	.56388E-02	2.293	0.1994	0.1783	50.50	50.44
24	1.642	1.850	.56642E-02	.56388E-02	2.293	0.1977	0.1747	50.52	50.45
25	1.663	1.839	.56642E-02	.56388E-02	2.291	0.1950	0.1756	50.53	50.45
26	1.650	1.843	.56642E-02	.56388E-02	2.290	0.1965	0.1752	50.51	50.44
27	1.647	1.847	.56642E-02	.56388E-02	2.290	0.1969	0.1748	50.51	50.43
28	1.648	1.832	.56642E-02	.56388E-02	2.291	0.1969	0.1763	50.50	50.43
29	0.391	0.422	.56642E-02	.56388E-02	0.525	0.1699	0.1752	37.01	36.94
30	0.416	0.458	.56642E-02	.56388E-02	0.526	0.1769	0.1583	36.93	36.92
31	0.477	0.458	.56642E-02	.56388E-02	0.526	0.1504	0.1616	36.80	36.85
32	0.436	0.468	.56642E-02	.56388E-02	0.527	0.1713	0.1588	36.60	36.67
33	0.381	0.440	.56642E-02	.56388E-02	0.527	0.1961	0.1688	36.62	36.61
34	0.378	0.419	.56642E-02	.56388E-02	0.531	0.1988	0.1785	36.32	36.30
35	0.351	0.395	.56642E-02	.56388E-02	0.525	0.2118	0.1674	36.36	36.34
36	0.352	0.367	.56642E-02	.56388E-02	0.523	0.2093	0.2010	36.36	36.37
37	0.332	0.391	.56642E-02	.56388E-02	0.521	0.2223	0.1876	36.38	36.36
38	0.367	0.403	.56642E-02	.56388E-02	0.530	0.2042	0.1852	36.41	36.41
39	0.373	0.396	.56642E-02	.56388E-02	0.528	0.2006	0.1879	36.45	36.43
40	0.384	0.419	.56642E-02	.56388E-02	0.524	0.1933	0.1761	36.45	36.45
41	0.403	0.409	.56642E-02	.56388E-02	0.526	0.1850	0.1815	36.46	36.47
42	0.373	0.421	.56642E-02	.56388E-02	0.528	0.2006	0.1769	36.49	36.47
43	2.536	2.966	.56642E-02	.56388E-02	3.653	0.2038	0.1736	60.36	60.14
44	2.546	3.035	.56642E-02	.56388E-02	3.651	0.2030	0.1690	60.34	60.10
45	2.544	2.985	.56642E-02	.56388E-02	3.651	0.2033	0.1724	60.34	60.13
46	2.554	2.978	.56642E-02	.56388E-02	3.650	0.2024	0.1728	60.35	60.14
47	2.544	2.966	.56642E-02	.56388E-02	3.650	0.2032	0.1735	60.34	60.14
48	2.533	2.982	.56642E-02	.56388E-02	3.647	0.2039	0.1724	60.34	60.13
49	2.544	2.973	.56642E-02	.56388E-02	3.648	0.2031	0.1729	60.32	60.12
50	2.538	2.966	.56642E-02	.56388E-02	3.655	0.2039	0.1737	60.47	60.24
51	2.546	2.948	.56642E-02	.56388E-02	3.655	0.2033	0.1748	60.44	60.23
52	2.551	2.951	.56642E-02	.56388E-02	3.651	0.2027	0.1744	60.43	60.23
53	2.559	2.964	.56642E-02	.56388E-02	3.647	0.2016	0.1735	60.40	60.20
54	2.551	2.979	.56642E-02	.56388E-02	3.646	0.2024	0.1725	60.37	60.16
55	2.536	2.970	.56642E-02	.56388E-02	3.647	0.2037	0.1731	60.36	60.15
56	1.788	1.777	.56388E-02	.56642E-02	2.311	0.1822	0.1841	51.48	51.51
57	1.764	1.747	.56388E-02	.56642E-02	2.310	0.1846	0.1872	51.35	51.41
58	1.770	1.740	.56388E-02	.56642E-02	2.309	0.1839	0.1879	51.25	51.30
59	1.762	1.755	.56388E-02	.56642E-02	2.309	0.1847	0.1863	51.19	51.25
60	1.741	1.733	.56388E-02	.56642E-02	2.306	0.1867	0.1864	51.14	51.19
61	1.797	1.813	.56388E-02	.56642E-02	2.317	0.1817	0.1810	51.69	51.72
62	1.801	1.773	.56388E-02	.56642E-02	2.320	0.1816	0.1853	51.57	51.62
63	1.814	1.783	.56388E-02	.56642E-02	2.317	0.1800	0.1840	51.49	51.55
64	1.806	1.784	.56388E-02	.56642E-02	2.319	0.1810	0.1841	51.46	51.51
65	1.793	1.767	.56388E-02	.56642E-02	2.317	0.1821	0.1835	51.44	51.49
66	1.794	1.748	.56388E-02	.56642E-02	2.312	0.1817	0.1873	51.33	51.40
67	1.799	1.743	.56388E-02	.56642E-02	2.314	0.1813	0.1879	51.32	51.37
68	1.807	1.758	.56388E-02	.56642E-02	2.313	0.1804	0.1863	51.30	51.37
69	1.754	1.712	.55372E-02	.56896E-02	2.305	0.1819	0.1915	51.17	51.22
70	1.754	1.703	.55372E-02	.56896E-02	2.303	0.1817	0.1923	51.13	51.19
71	1.784	1.682	.55372E-02	.56896E-02	2.304	0.1788	0.1946	51.10	51.17
72	1.776	1.692	.55372E-02	.56896E-02	2.309	0.1800	0.1941	51.06	51.14
73	1.773	1.688	.55372E-02	.56896E-02	2.304	0.1799	0.1941	51.04	51.14

TABLE F13 (continued)

74	1.755	1.686	.55372E-02	.56896E-02	2.301	0.1815	0.1941	50.97	51.05
75	1.747	1.668	.55372E-02	.56896E-02	2.302	0.1824	0.1963	50.88	50.95
76	1.745	1.673	.55372E-02	.56896E-02	2.305	0.1829	0.1959	50.69	50.96
77	1.742	1.697	.55372E-02	.56896E-02	2.305	0.1832	0.1932	50.69	50.94
78	1.740	1.654	.55372E-02	.56896E-02	2.298	0.1829	0.1976	50.73	50.82
79	1.761	1.684	.55372E-02	.56896E-02	2.301	0.1809	0.1944	50.79	50.89
80	1.790	1.664	.55372E-02	.56896E-02	2.304	0.1782	0.1969	50.81	50.90
81	3.104	2.939	.11150E-01	.11200E-01	2.285	0.2052	0.2177	50.45	50.56
82	3.119	2.906	.11150E-01	.11200E-01	2.289	0.2045	0.2205	50.14	50.29
83	3.102	2.925	.11150E-01	.11200E-01	2.285	0.2054	0.2187	50.30	50.45
84	3.092	2.902	.11150E-01	.11200E-01	2.285	0.2060	0.2204	50.22	50.36
85	3.071	2.896	.11150E-01	.11200E-01	2.286	0.2075	0.2210	50.11	50.27
86	3.071	2.909	.11150E-01	.11200E-01	2.286	0.2075	0.2201	50.09	50.23
87	3.066	2.913	.11150E-01	.11200E-01	2.286	0.2078	0.2197	50.09	50.25
88	3.196	2.982	.11150E-01	.11200E-01	2.283	0.1992	0.2144	50.03	50.77
89	3.104	2.904	.11150E-01	.11200E-01	2.280	0.2048	0.2198	50.42	50.56
90	3.102	2.916	.11150E-01	.11200E-01	2.282	0.2051	0.2191	50.25	50.41
91	3.105	2.915	.11150E-01	.11200E-01	2.286	0.2052	0.2196	50.22	50.30
92	3.116	2.904	.11150E-01	.11200E-01	2.294	0.2052	0.2212	50.21	50.33
93	3.110	2.943	.11150E-01	.11200E-01	2.294	0.2056	0.2182	50.32	50.47
94	0.713	0.708	.11150E-01	.11200E-01	0.529	0.2067	0.2089	36.35	36.37
95	0.721	0.687	.11150E-01	.11200E-01	0.528	0.2043	0.2153	36.46	36.51
96	0.721	0.701	.11150E-01	.11200E-01	0.529	0.2044	0.2111	36.46	36.49
97	0.737	0.722	.11150E-01	.11200E-01	0.520	0.1906	0.2015	36.01	36.62
98	0.740	0.712	.11150E-01	.11200E-01	0.519	0.1956	0.2042	36.00	36.62
99	0.721	0.712	.11150E-01	.11200E-01	0.519	0.2007	0.2042	36.58	36.59
100	0.726	0.715	.11150E-01	.11200E-01	0.520	0.1997	0.2037	36.57	36.57
101	0.715	0.712	.11150E-01	.11200E-01	0.519	0.2021	0.2050	36.37	36.37
102	0.745	0.706	.11150E-01	.11200E-01	0.524	0.1960	0.2073	36.53	36.57
103	0.737	0.712	.11150E-01	.11200E-01	0.525	0.1987	0.2067	36.55	36.57
104	0.745	0.708	.11150E-01	.11200E-01	0.526	0.1965	0.2076	36.55	36.37
105	0.715	0.701	.11150E-01	.11200E-01	0.524	0.2044	0.2095	36.53	36.56
106	0.707	0.645	.11150E-01	.11200E-01	0.526	0.2072	0.2280	36.46	36.50
107	5.081	4.632	.11150E-01	.11200E-01	3.033	0.1993	0.2196	60.22	60.52
108	5.025	4.541	.11150E-01	.11200E-01	3.032	0.2015	0.2239	60.06	60.38
109	4.974	4.550	.11150E-01	.11200E-01	3.025	0.2032	0.2231	59.91	60.20
110	5.111	4.640	.11150E-01	.11200E-01	3.033	0.1981	0.2192	60.30	60.57
111	4.973	4.543	.11150E-01	.11200E-01	3.029	0.2035	0.2237	60.07	60.37
112	4.958	4.535	.11150E-01	.11200E-01	3.025	0.2038	0.2238	59.92	60.22
113	4.995	4.533	.11150E-01	.11200E-01	3.027	0.2023	0.2240	59.00	60.13
114	4.966	4.548	.11150E-01	.11200E-01	3.026	0.2035	0.2232	59.09	59.99
115	4.954	4.506	.11150E-01	.11200E-01	3.023	0.2039	0.2251	59.62	59.93
116	4.931	4.518	.11150E-01	.11200E-01	3.021	0.2047	0.2244	59.52	59.83
117	4.947	4.527	.11150E-01	.11200E-01	3.028	0.2044	0.2244	59.47	59.76
118	4.925	4.536	.11150E-01	.11200E-01	3.024	0.2051	0.2237	59.30	59.60
119	4.926	4.543	.11150E-01	.11200E-01	3.029	0.2054	0.2237	59.27	59.55
120	2.958	3.324	.11200E-01	.11150E-01	2.285	0.2163	0.1916	51.20	51.01
121	2.911	3.256	.11200E-01	.11150E-01	2.284	0.2197	0.1955	51.09	50.91
122	2.906	3.295	.11200E-01	.11150E-01	2.284	0.2200	0.1932	50.98	50.76
123	2.899	3.232	.11200E-01	.11150E-01	2.287	0.2209	0.1972	50.95	50.67
124	2.913	3.256	.11200E-01	.11150E-01	2.284	0.2195	0.1957	50.72	50.54
125	2.892	3.188	.11200E-01	.11150E-01	2.284	0.2211	0.1997	50.62	50.46
126	2.890	3.219	.11200E-01	.11150E-01	2.286	0.2214	0.1979	50.58	50.41
127	2.893	3.184	.11200E-01	.11150E-01	2.281	0.2206	0.1997	50.00	50.44
128	2.996	3.312	.11200E-01	.11150E-01	2.283	0.2134	0.1922	51.13	50.93
129	2.895	3.316	.11200E-01	.11150E-01	2.284	0.2209	0.1920	51.04	50.83
130	2.914	3.281	.11200E-01	.11150E-01	2.285	0.2195	0.1941	50.98	50.76
131	2.904	3.238	.11200E-01	.11150E-01	2.284	0.2202	0.1966	50.85	50.67
132	2.908	3.264	.11200E-01	.11150E-01	2.284	0.2199	0.1950	50.71	50.53
133	3.162	3.068	.11210E-01	.11170E-01	2.300	0.2039	0.2094	50.91	50.98
134	3.157	3.071	.11210E-01	.11170E-01	2.296	0.2038	0.2088	50.82	50.93
135	3.150	3.028	.11210E-01	.11170E-01	2.300	0.2047	0.2122	[illegible]	50.86
136	3.162	3.058	.11210E-01	.11170E-01	2.304	0.2042	0.2104	[illegible]	50.99
137	3.158	3.044	.11210E-01	.11170E-01	2.300	0.2042	0.2110	50.77	50.89
138	3.109	3.056	.11210E-01	.11170E-01	2.297	0.2070	0.2099	50.40	50.48
139	3.180	3.037	.11210E-01	.11170E-01	2.297	0.2024	0.2113	50.94	51.06
140	3.107	3.024	.11210E-01	.11170E-01	2.280	0.2056	0.2105	50.83	50.91
141	3.108	2.980	.11210E-01	.11170E-01	2.282	0.2058	0.2139	50.69	50.77
142	3.087	3.024	.11210E-01	.11170E-01	2.280	0.2069	0.2105	50.55	50.58
143	3.093	2.954	.11210E-01	.11170E-01	2.285	0.2070	0.2159	50.45	50.54
144	3.086	3.015	.11210E-01	.11170E-01	2.286	0.2078	0.2119	50.35	50.46
145	3.107	3.015	.11210E-01	.11170E-01	2.284	0.2060	0.2115	50.32	50.43
146	3.187	3.071	.11170E-01	.11210E-01	2.311	0.2025	0.2109	50.39	50.42
147	3.195	3.082	.11170E-01	.11210E-01	2.303	0.2013	0.2094	50.34	50.45
148	3.156	3.002	.11170E-01	.11210E-01	2.305	0.2040	0.2152	50.22	50.33
149	3.151	2.999	.11170E-01	.11210E-01	2.301	0.2039	0.2156	50.21	50.33
150	3.161	2.995	.11170E-01	.11210E-01	2.305	0.2036	0.2157	50.18	50.29

TABLE F13 (continued)

151	3.154	3.044	.11170E-01	.11210E-01	2.303	0.2039	0.2120	50.16	50.25
152	3.172	3.075	.11170E-01	.11210E-01	2.305	0.2029	0.2100	50.14	50.23
153	3.181	3.061	.11170E-01	.11210E-01	2.305	0.2024	0.2110	50.11	50.21
154	3.149	3.028	.11170E-01	.11210E-01	2.306	0.2045	0.2134	50.04	50.16
155	3.146	3.035	.11170E-01	.11210E-01	2.305	0.2046	0.2128	50.05	50.17
156	3.133	3.033	.11170E-01	.11210E-01	2.306	0.2056	0.2131	50.03	50.16
157	3.166	3.065	.11170E-01	.11210E-01	2.300	0.2027	0.2103	50.42	50.48
158	3.155	3.046	.11170E-01	.11210E-01	2.298	0.2034	0.2114	50.30	50.42
159	3.649	4.049	.11150E-01	.11200E-01	2.294	0.1752	0.1586	50.50	50.27
160	3.618	4.043	.11150E-01	.11200E-01	2.303	0.1774	0.1595	50.41	50.18
161	3.600	3.977	.11150E-01	.11200E-01	2.300	0.1781	0.1619	50.29	50.09
162	3.619	4.047	.11150E-01	.11200E-01	2.302	0.1773	0.1593	50.20	49.96
163	3.582	4.009	.11150E-01	.11200E-01	2.296	0.1766	0.1603	50.16	49.95
164	3.602	3.950	.11150E-01	.11200E-01	2.290	0.1777	0.1628	50.06	49.87
165	3.608	3.947	.11150E-01	.11200E-01	2.296	0.1774	0.1629	50.00	49.82
166	3.592	3.980	.11150E-01	.11200E-01	2.293	0.1779	0.1613	49.87	49.60
167	3.574	3.948	.11150E-01	.11200E-01	2.294	0.1769	0.1627	49.83	49.64
168	3.577	4.002	.11150E-01	.11200E-01	2.295	0.1788	0.1606	49.73	49.53
169	3.583	3.990	.11150E-01	.11200E-01	2.297	0.1787	0.1612	49.73	49.53
170	3.590	3.952	.11150E-01	.11200E-01	2.299	0.1765	0.1628	49.80	49.62
171	3.588	3.937	.11150E-01	.11200E-01	2.294	0.1783	0.1632	49.80	49.62
172	0.809	0.907	.11150E-01	.11200E-01	0.526	0.1812	0.1624	36.06	36.05
173	0.875	0.938	.11150E-01	.11200E-01	0.526	0.1676	0.1571	36.02	35.99
174	0.859	0.853	.11150E-01	.11200E-01	0.525	0.1704	0.1665	35.93	35.91
175	0.848	0.877	.11150E-01	.11200E-01	0.525	0.1726	0.1676	35.90	35.88
176	0.812	0.908	.11150E-01	.11200E-01	0.526	0.1805	0.1622	35.86	35.83
177	0.823	0.901	.11150E-01	.11200E-01	0.526	0.1762	0.1636	35.83	35.81
178	0.818	0.914	.11150E-01	.11200E-01	0.526	0.1793	0.1611	35.83	35.78
179	0.823	0.889	.11150E-01	.11200E-01	0.526	0.1781	0.1656	35.83	35.79
180	0.832	0.896	.11150E-01	.11200E-01	0.527	0.1767	0.1647	35.83	35.81
181	0.826	0.849	.11150E-01	.11200E-01	0.525	0.1772	0.1732	35.86	35.85
182	0.821	0.898	.11150E-01	.11200E-01	0.527	0.1791	0.1643	35.85	35.82
183	0.823	0.886	.11150E-01	.11200E-01	0.526	0.1782	0.1663	35.86	35.84
184	0.837	0.898	.11150E-01	.11200E-01	0.527	0.1756	0.1643	35.85	35.82
185	5.550	6.244	.11150E-01	.11200E-01	3.020	0.1815	0.1623	58.85	58.51
186	5.512	6.180	.11150E-01	.11200E-01	3.021	0.1831	0.1640	58.99	58.64
187	5.515	6.194	.11150E-01	.11200E-01	3.018	0.1829	0.1635	58.97	58.62
188	5.533	6.232	.11150E-01	.11200E-01	3.023	0.1825	0.1628	59.46	59.10
189	5.539	6.250	.11150E-01	.11200E-01	3.019	0.1821	0.1621	59.12	58.75
190	5.695	6.388	.11150E-01	.11200E-01	3.038	0.1761	0.1595	60.05	59.70
191	5.602	6.338	.11150E-01	.11200E-01	3.036	0.1809	0.1606	59.82	59.43
192	5.575	6.348	.11150E-01	.11200E-01	3.034	0.1817	0.1603	59.64	59.23
193	5.543	6.277	.11150E-01	.11200E-01	3.031	0.1826	0.1619	59.23	58.83
194	5.594	6.279	.11150E-01	.11200E-01	3.028	0.1808	0.1616	59.12	58.76
195	5.556	6.265	.11150E-01	.11200E-01	3.032	0.1822	0.1623	59.03	58.65
196	5.538	6.225	.11150E-01	.11200E-01	3.025	0.1825	0.1631	58.98	58.63
197	5.556	6.218	.11150E-01	.11200E-01	3.026	0.1820	0.1634	59.01	58.60
198	3.770	4.020	.11200E-01	.11150E-01	2.301	0.1709	0.1596	50.33	50.22
199	3.715	3.969	.11200E-01	.11150E-01	2.301	0.1734	0.1616	50.23	50.13
200	3.694	3.918	.11200E-01	.11150E-01	2.301	0.1744	0.1637	50.18	50.08
201	3.737	3.953	.11200E-01	.11150E-01	2.301	0.1724	0.1623	50.11	50.02
202	3.735	3.972	.11200E-01	.11150E-01	2.300	0.1724	0.1614	50.07	49.97
203	3.698	3.945	.11200E-01	.11150E-01	2.299	0.1741	0.1625	50.01	49.91
204	3.693	3.929	.11200E-01	.11150E-01	2.300	0.1744	0.1632	50.00	49.90
205	3.677	3.914	.11200E-01	.11150E-01	2.300	0.1751	0.1636	49.97	49.87
206	3.685	3.904	.11200E-01	.11150E-01	2.300	0.1748	0.1643	49.95	49.86
207	3.696	3.911	.11200E-01	.11150E-01	2.303	0.1744	0.1641	49.90	49.81
208	3.710	3.913	.11200E-01	.11150E-01	2.323	0.1754	0.1655	49.90	49.81
209	3.718	3.929	.11200E-01	.11150E-01	2.323	0.1750	0.1646	49.85	49.79
210	3.673	3.931	.11200E-01	.11150E-01	2.323	0.1771	0.1647	49.77	49.66
211	3.643	4.062	.11210E-01	.11170E-01	2.314	0.1760	0.1591	49.91	49.68
212	3.619	4.076	.11210E-01	.11170E-01	2.314	0.1792	0.1565	49.93	49.71
213	3.632	4.068	.11210E-01	.11170E-01	2.313	0.1785	0.1566	49.92	49.70
214	3.632	4.067	.11210E-01	.11170E-01	2.311	0.1783	0.1587	49.92	49.71
215	3.632	4.074	.11210E-01	.11170E-01	2.311	0.1783	0.1564	49.92	49.70
216	3.612	4.104	.11210E-01	.11170E-01	2.306	0.1769	0.1569	50.42	50.19
217	3.656	4.110	.11210E-01	.11170E-01	2.307	0.1769	0.1568	50.32	50.09
218	3.619	4.076	.11210E-01	.11170E-01	2.307	0.1766	0.1561	50.24	50.01
219	3.611	4.072	.11210E-01	.11170E-01	2.308	0.1791	0.1583	50.19	49.95
220	3.660	4.066	.11210E-01	.11170E-01	2.306	0.1767	0.1585	50.10	49.89
221	3.642	4.058	.11210E-01	.11170E-01	2.310	0.1778	0.1590	50.07	49.85
222	3.629	4.064	.11210E-01	.11170E-01	2.310	0.1784	0.1587	50.01	49.76
223	3.608	4.070	.11210E-01	.11170E-01	2.307	0.1792	0.1583	49.94	49.71
224	3.565	3.990	.11170E-01	.11210E-01	2.291	0.1764	0.1609	49.78	49.57
225	3.565	3.994	.11170E-01	.11210E-01	2.291	0.1755	0.1605	49.76	49.58
226	3.593	4.016	.11170E-01	.11210E-01	2.290	0.1780	0.1598	49.74	49.53
227	3.593	3.983	.11170E-01	.11210E-01	2.291	0.1760	0.1612	49.76	49.59

228	3.606	3.952	.11170E-01	.11210E-01	2.291	0.1774	0.1612	49.79	49.60
229	3.583	4.028	.11170E-01	.11210E-01	2.286	0.1752	0.1591	49.68	49.46
230	3.560	4.029	.11170E-01	.11210E-01	2.289	0.1763	0.1593	49.71	49.49
231	3.588	4.031	.11170E-01	.11210E-01	2.290	0.1782	0.1592	49.71	49.49
232	3.596	3.964	.11170E-01	.11210E-01	2.291	0.1779	0.1620	49.60	49.61
233	3.598	3.970	.11170E-01	.11210E-01	2.292	0.1779	0.1618	49.63	49.64
234	3.595	3.985	.11170E-01	.11210E-01	2.292	0.1780	0.1612	49.56	49.66
235	3.598	3.978	.11170E-01	.11210E-01	2.292	0.1779	0.1614	49.63	49.65
236	3.590	4.001	.11170E-01	.11210E-01	2.292	0.1763	0.1606	49.67	49.67
237	3.576	4.128	.11150E-01	.11200E-01	2.296	0.1741	0.1557	49.76	49.52
238	3.703	4.116	.11150E-01	.11200E-01	2.296	0.1728	0.1562	49.67	49.46
239	3.741	4.146	.11150E-01	.11200E-01	2.293	0.1708	0.1546	49.60	49.20
240	3.736	4.138	.11150E-01	.11200E-01	2.297	0.1714	0.1554	49.57	49.37
241	3.679	4.129	.11150E-01	.11200E-01	2.299	0.1742	0.1559	49.73	49.51
242	3.679	4.106	.11150E-01	.11200E-01	2.297	0.1741	0.1567	49.74	49.51
243	3.681	4.115	.11150E-01	.11200E-01	2.296	0.1739	0.1562	49.74	49.52
244	3.676	4.112	.11150E-01	.11200E-01	2.296	0.1741	0.1564	49.73	49.52
245	3.673	4.109	.11150E-01	.11200E-01	2.296	0.1743	0.1565	49.74	49.53
246	3.671	4.116	.11150E-01	.11200E-01	2.296	0.1744	0.1562	49.75	49.52
247	3.684	4.104	.11150E-01	.11200E-01	2.296	0.1738	0.1567	49.75	49.53
248	3.697	4.113	.11150E-01	.11200E-01	2.297	0.1732	0.1564	49.77	49.55
249	3.681	4.113	.11150E-01	.11200E-01	2.297	0.1739	0.1564	49.76	49.55
250	0.886	0.955	.11150E-01	.11200E-01	0.527	0.1658	0.1546	35.66	35.65
251	0.862	0.916	.11150E-01	.11200E-01	0.527	0.1706	0.1612	35.67	35.65
252	0.873	0.957	.11150E-01	.11200E-01	0.527	0.1684	0.1583	35.66	35.63
253	0.870	0.940	.11150E-01	.11200E-01	0.528	0.1693	0.1573	35.65	35.61
254	0.859	0.952	.11150E-01	.11200E-01	0.528	0.1715	0.1554	35.64	35.80
255	0.892	0.936	.11150E-01	.11200E-01	0.527	0.1646	0.1578	35.79	35.77
256	0.889	0.936	.11150E-01	.11200E-01	0.527	0.1653	0.1576	35.79	35.77
257	0.911	0.939	.11150E-01	.11200E-01	0.529	0.1620	0.1579	35.78	35.77
258	0.903	0.960	.11150E-01	.11200E-01	0.528	0.1631	0.1541	35.76	35.75
259	0.911	0.957	.11150E-01	.11200E-01	0.527	0.1613	0.1542	35.74	35.73
260	0.914	0.960	.11150E-01	.11200E-01	0.527	0.1608	0.1537	35.75	35.73
261	0.914	0.946	.11150E-01	.11200E-01	0.527	0.1606	0.1562	35.75	35.74
262	0.917	0.939	.11150E-01	.11200E-01	0.528	0.1607	0.1576	35.75	35.74
263	5.776	6.522	.11150E-01	.11200E-01	3.043	0.1756	0.1564	58.95	58.61
264	5.781	6.520	.11150E-01	.11200E-01	3.042	0.1756	0.1564	59.01	58.64
265	5.749	6.517	.11150E-01	.11200E-01	3.046	0.1768	0.1567	59.11	58.71
266	5.756	6.494	.11150E-01	.11200E-01	3.043	0.1764	0.1571	59.13	58.74
267	5.753	6.492	.11150E-01	.11200E-01	3.044	0.1765	0.1571	59.14	58.76
268	5.756	6.495	.11150E-01	.11200E-01	3.043	0.1764	0.1571	59.16	58.77
269	5.753	6.501	.11150E-01	.11200E-01	3.042	0.1764	0.1568	59.15	58.76
270	5.782	6.507	.11150E-01	.11200E-01	3.042	0.1756	0.1567	59.19	58.82
271	5.792	6.522	.11150E-01	.11200E-01	3.042	0.1753	0.1564	59.21	58.82
272	5.784	6.526	.11150E-01	.11200E-01	3.043	0.1755	0.1563	59.21	58.83
273	5.784	6.538	.11150E-01	.11200E-01	3.043	0.1756	0.1560	59.21	58.83
274	5.761	6.499	.11150E-01	.11200E-01	3.041	0.1762	0.1569	59.17	58.77
275	5.777	6.516	.11150E-01	.11200E-01	3.039	0.1756	0.1564	59.17	58.78
276	3.823	4.231	.11200E-01	.11150E-01	2.302	0.1686	0.1517	50.74	50.53
277	3.752	4.147	.11200E-01	.11150E-01	2.302	0.1716	0.1546	50.67	50.48
278	3.762	4.140	.11200E-01	.11150E-01	2.303	0.1714	0.1551	50.66	50.47
279	3.770	4.141	.11200E-01	.11150E-01	2.306	0.1710	0.1552	50.61	50.43
280	3.779	4.145	.11200E-01	.11150E-01	2.303	0.1707	0.1549	50.58	50.41
281	3.784	4.180	.11200E-01	.11150E-01	2.304	0.1704	0.1536	50.55	50.36
282	3.740	4.169	.11200E-01	.11150E-01	2.305	0.1726	0.1542	50.50	50.31
283	3.772	4.110	.11200E-01	.11150E-01	2.302	0.1706	0.1561	50.37	50.19
284	3.754	4.115	.11200E-01	.11150E-01	2.302	0.1717	0.1559	50.36	50.19
285	3.772	4.138	.11200E-01	.11150E-01	2.302	0.1708	0.1550	50.37	50.21
286	3.738	4.116	.11200E-01	.11150E-01	2.305	0.1727	0.1561	50.42	50.24
287	3.737	4.110	.11200E-01	.11150E-01	2.303	0.1726	0.1560	50.45	50.26
288	3.732	4.132	.11200E-01	.11150E-01	2.305	0.1730	0.1555	50.46	50.26
289	4.034	3.807	.11210E-01	.11170E-01	2.288	0.1569	0.1679	50.25	50.39
290	4.021	3.815	.11210E-01	.11170E-01	2.288	0.1595	0.1675	50.27	50.43
291	4.037	3.801	.11210E-01	.11170E-01	2.289	0.1569	0.1682	50.26	50.41
292	4.040	3.802	.11210E-01	.11170E-01	2.269	0.1556	0.1651	50.24	50.40
293	4.080	3.872	.11210E-01	.11170E-01	2.271	0.1560	0.1633	50.79	50.95
294	4.025	3.821	.11210E-01	.11170E-01	2.279	0.1566	0.1605	50.72	50.80
295	4.026	3.702	.11210E-01	.11170E-01	2.279	0.1567	0.1719	50.64	50.73
296	4.000	3.922	.11210E-01	.11170E-01	2.279	0.1597	0.1622	50.54	50.74
297	4.022	3.816	.11210E-01	.11170E-01	2.277	0.1587	0.1660	50.46	50.60
298	4.037	3.788	.11210E-01	.11170E-01	2.273	0.1578	0.1676	50.24	50.37
299	3.992	3.771	.11210E-01	.11170E-01	2.274	0.1596	0.1684	50.21	50.38
300	4.003	3.779	.11210E-01	.11170E-01	2.274	0.1592	0.1690	50.19	50.34
301	3.992	3.783	.11210E-01	.11170E-01	2.275	0.1597	0.1679	50.18	50.33
302	4.015	3.696	.11170E-01	.11210E-01	2.277	0.1583	0.1720	49.99	50.19
303	4.013	3.699	.11170E-01	.11210E-01	2.281	0.1588	0.1726	50.00	50.19
304	3.984	3.766	.11170E-01	.11210E-01	2.280	0.1599	0.1697	49.92	50.09

305	3.992	3.758	.11170E-01	.11210E-01	2.281	0.1596	0.1701	49.93	50.11
306	3.978	3.746	.11170E-01	.11210E-01	2.281	0.1601	0.1706	49.92	50.10
307	3.996	3.693	.11170E-01	.11210E-01	2.274	0.1589	0.1726	49.74	49.93
308	4.001	3.686	.11170E-01	.11210E-01	2.274	0.1587	0.1729	49.74	49.94
309	3.999	3.673	.11170E-01	.11210E-01	2.275	0.1589	0.1736	49.75	49.96
310	3.985	3.659	.11170E-01	.11210E-01	2.276	0.1595	0.1743	49.77	49.98
311	3.961	3.694	.11170E-01	.11210E-01	2.277	0.1605	0.1727	49.81	50.01
312	3.958	3.685	.11170E-01	.11210E-01	2.276	0.1606	0.1731	49.82	50.00
313	3.961	3.682	.11170E-01	.11210E-01	2.276	0.1604	0.1732	49.81	50.00
314	3.974	3.686	.11170E-01	.11210E-01	2.276	0.1599	0.1731	49.80	49.99
315	2.156	2.232	.56642E-02	.56388E-02	2.289	0.1503	0.1440	49.82	49.85
316	2.143	2.184	.56642E-02	.56388E-02	2.284	0.1509	0.1474	49.86	49.90
317	2.127	2.174	.56642E-02	.56388E-02	2.284	0.1521	0.1481	49.91	49.93
318	2.142	2.172	.56642E-02	.56388E-02	2.286	0.1511	0.1484	49.93	49.94
319	2.158	2.188	.56642E-02	.56388E-02	2.288	0.1501	0.1474	49.94	49.95
320	2.145	2.170	.56642E-02	.56388E-02	2.286	0.1509	0.1485	49.95	49.97
321	2.140	2.173	.56642E-02	.56388E-02	2.285	0.1512	0.1483	49.96	49.97
322	2.153	2.187	.56642E-02	.56388E-02	2.290	0.1505	0.1470	49.99	50.00
323	2.142	2.187	.56642E-02	.56388E-02	2.287	0.1512	0.1474	50.00	50.01
324	2.153	2.200	.56642E-02	.56388E-02	2.284	0.1502	0.1464	50.00	50.02
325	2.153	2.191	.56642E-02	.56388E-02	2.289	0.1506	0.1473	50.00	50.02
326	2.144	2.231	.56642E-02	.56388E-02	2.291	0.1513	0.1448	50.09	50.12
327	2.160	2.235	.56642E-02	.56388E-02	2.295	0.1505	0.1446	50.15	50.15
328	0.527	0.545	.56642E-02	.56388E-02	0.527	0.1418	0.1362	36.11	36.11
329	0.543	0.537	.56642E-02	.56388E-02	0.527	0.1375	0.1383	36.11	36.13
330	0.527	0.537	.56642E-02	.56388E-02	0.528	0.1419	0.1385	36.09	36.11
331	0.532	0.546	.56642E-02	.56388E-02	0.528	0.1404	0.1362	36.08	36.11
332	0.521	0.528	.56642E-02	.56388E-02	0.528	0.1434	0.1410	36.09	36.11
333	0.516	0.528	.56642E-02	.56388E-02	0.528	0.1449	0.1410	36.09	36.11
334	0.513	0.539	.56642E-02	.56388E-02	0.528	0.1457	0.1381	36.09	36.11
335	0.513	0.520	.56642E-02	.56388E-02	0.528	0.1457	0.1430	36.05	36.07
336	0.502	0.525	.56642E-02	.56388E-02	0.528	0.1489	0.1418	36.07	36.08
337	0.513	0.523	.56642E-02	.56388E-02	0.528	0.1457	0.1422	36.07	36.10
338	0.510	0.512	.56642E-02	.56388E-02	0.528	0.1465	0.1452	36.05	36.07
339	0.496	0.518	.56642E-02	.56388E-02	0.528	0.1506	0.1436	36.07	36.10
340	0.518	0.518	.56642E-02	.56388E-02	0.528	0.1442	0.1436	36.08	36.10
341	3.400	3.514	.56642E-02	.56388E-02	3.032	0.1510	0.1457	60.08	60.05
342	3.400	3.505	.56642E-02	.56388E-02	3.035	0.1514	0.1462	59.85	59.88
343	3.395	3.507	.56642E-02	.56388E-02	3.034	0.1516	0.1461	59.77	59.75
344	3.358	3.459	.56642E-02	.56388E-02	3.029	0.1531	0.1479	59.58	59.55
345	3.339	3.479	.56642E-02	.56388E-02	3.030	0.1517	0.1471	59.52	59.50
346	3.400	3.482	.56642E-02	.56388E-02	3.032	0.1513	0.1471	59.35	59.47
347	3.393	3.475	.56642E-02	.56388E-02	3.032	0.1516	0.1473	59.41	59.44
348	3.407	3.483	.56642E-02	.56388E-02	3.039	0.1512	0.1473	59.28	59.28
349	3.393	3.467	.56642E-02	.56388E-02	3.036	0.1517	0.1476	59.30	59.29
350	3.401	3.461	.56642E-02	.56388E-02	3.034	0.1513	0.1481	59.29	59.30
351	3.391	3.459	.56642E-02	.56388E-02	3.034	0.1518	0.1481	59.30	59.30
352	3.383	3.438	.56642E-02	.56388E-02	3.035	0.1522	0.1490	59.32	59.34
353	3.302	3.448	.56642E-02	.56388E-02	3.035	0.1531	0.1466	59.36	59.37
354	2.323	2.158	.56388E-02	.56642E-02	2.290	0.1369	0.1502	50.58	50.70
355	2.230	2.154	.56388E-02	.56642E-02	2.293	0.1414	0.1507	50.52	50.64
356	2.246	2.162	.56388E-02	.56642E-02	2.293	0.1439	0.1502	50.45	50.50
357	2.247	2.150	.56388E-02	.56642E-02	2.293	0.1439	0.1511	50.42	50.50
358	2.292	2.155	.56388E-02	.56642E-02	2.292	0.1409	0.1506	50.38	50.48
359	2.308	2.153	.56388E-02	.56642E-02	2.291	0.1399	0.1507	50.32	50.44
360	2.316	2.261	.56388E-02	.56642E-02	2.292	0.1395	0.1435	50.31	50.38
361	2.237	2.081	.56388E-02	.56642E-02	2.287	0.1441	0.1556	50.22	50.34
362	2.261	2.176	.56388E-02	.56642E-02	2.291	0.1429	0.1491	50.25	50.37
363	2.240	2.253	.56388E-02	.56642E-02	2.289	0.1441	0.1439	50.24	50.29
364	2.272	2.119	.56388E-02	.56642E-02	2.287	0.1419	0.1528	50.16	50.25
365	2.251	2.131	.56388E-02	.56642E-02	2.285	0.1431	0.1519	50.18	50.27
366	2.258	2.501	.56388E-02	.56642E-02	2.280	0.1427	0.1204	50.18	50.08
367	2.253	2.011	.56896E-02	.55372E-02	2.284	0.1442	0.1572	49.09	49.87
368	2.255	2.051	.56896E-02	.55372E-02	2.283	0.1447	0.1541	49.73	49.90
369	2.239	2.082	.56896E-02	.55372E-02	2.283	0.1450	0.1516	49.76	49.94
370	2.268	2.103	.56896E-02	.55372E-02	2.283	0.1432	0.1503	49.79	49.96
371	2.290	2.079	.56896E-02	.55372E-02	2.283	0.1419	0.1520	49.81	49.98
372	2.313	2.107	.56896E-02	.55372E-02	2.284	0.1404	0.1500	49.56	50.00
373	2.297	2.117	.56896E-02	.55372E-02	2.280	0.1411	0.1490	49.07	50.01
374	2.295	2.134	.56896E-02	.55372E-02	2.280	0.1413	0.1479	49.87	49.99
375	2.292	2.110	.56896E-02	.55372E-02	2.282	0.1416	0.1497	49.05	49.98
376	2.274	2.118	.56896E-02	.55372E-02	2.276	0.1424	0.1488	49.01	49.96
377	2.305	2.124	.56896E-02	.55372E-02	2.279	0.1466	0.1405	49.04	49.95
378	2.295	2.112	.56896E-02	.55372E-02	2.283	0.1415	0.1497	49.03	49.97
379	2.303	2.126	.56896E-02	.55372E-02	2.282	0.1410	0.1406	49.55	49.99
380	2.204	2.132	.55372E-02	.56896E-02	2.278	0.1431	0.1519	50.46	50.51
381	2.204	2.145	.55372E-02	.56896E-02	2.273	0.1425	0.1507	50.41	50.40

382	2.218	2.109	.55372E-02	.56896E-02	2.275	0.1420	0.1535	50.30	50.40
383	2.194	2.090	.55372E-02	.56896E-02	2.278	0.1437	0.1550	50.24	50.31
384	2.181	2.138	.55372E-02	.56896E-02	2.273	0.1443	0.1512	50.21	50.25
385	2.206	2.137	.55372E-02	.56896E-02	2.275	0.1428	0.1514	50.11	50.19
386	2.200	2.121	.55372E-02	.56896E-02	2.275	0.1431	0.1525	50.07	50.18
387	2.195	2.132	.55372E-02	.56896E-02	2.275	0.1435	0.1516	50.06	50.16
388	2.179	2.081	.55372E-02	.56896E-02	2.275	0.1445	0.1555	50.02	50.13
389	2.182	2.074	.55372E-02	.56896E-02	2.278	0.1445	0.1562	49.99	50.10
390	2.175	2.118	.55372E-02	.56896E-02	2.279	0.1451	0.1531	49.89	49.90
391	2.153	2.111	.55372E-02	.56896E-02	2.276	0.1464	0.1534	49.91	49.97
392	2.164	2.116	.55372E-02	.56896E-02	2.274	0.1455	0.1528	49.90	49.96
393	2.238	2.156	.56642E-02	.56388E-02	2.296	0.1453	0.1501	49.98	50.08
394	2.257	2.178	.56642E-02	.56388E-02	2.301	0.1444	0.1489	50.02	50.16
395	2.291	2.159	.56642E-02	.56388E-02	2.301	0.1422	0.1502	50.06	50.19
396	2.301	2.161	.56642E-02	.56388E-02	2.296	0.1413	0.1497	50.11	50.23
397	2.317	2.161	.56642E-02	.56388E-02	2.295	0.1403	0.1497	50.11	50.23
398	2.285	2.162	.56642E-02	.56388E-02	2.298	0.1424	0.1498	50.17	50.28
399	2.245	2.177	.56642E-02	.56388E-02	2.296	0.1448	0.1487	50.21	50.31
400	2.248	2.188	.56642E-02	.56388E-02	2.298	0.1448	0.1481	50.23	50.36
401	2.271	2.173	.56642E-02	.56388E-02	2.296	0.1431	0.1490	50.26	50.40
402	2.290	2.175	.56642E-02	.56388E-02	2.296	0.1420	0.1488	50.28	50.41
403	2.319	2.174	.56642E-02	.56388E-02	2.301	0.1405	0.1493	50.32	50.43
404	2.314	2.164	.56642E-02	.56388E-02	2.301	0.1409	0.1499	50.32	50.43
405	2.290	2.178	.56642E-02	.56388E-02	2.299	0.1422	0.1486	50.28	50.40
406	3.584	3.393	.56642E-02	.56388E-02	3.035	0.1430	0.1510	59.31	59.52
407	3.586	3.307	.56642E-02	.56388E-02	3.032	0.1434	0.1520	59.39	59.58
408	3.591	3.373	.56642E-02	.56388E-02	3.037	0.1434	0.1520	59.43	59.62
409	3.560	3.388	.56642E-02	.56388E-02	3.635	0.1446	0.1512	59.46	59.65
410	3.570	3.411	.56642E-02	.56388E-02	3.034	0.1441	0.1502	59.49	59.70
411	3.578	3.415	.56642E-02	.56388E-02	3.630	0.1437	0.1499	59.50	59.70
412	3.583	3.418	.56642E-02	.56388E-02	3.033	0.1436	0.1498	59.50	59.69
413	3.583	3.412	.56642E-02	.56388E-02	3.036	0.1437	0.1502	59.50	59.70
414	3.601	3.426	.56642E-02	.56388E-02	3.633	0.1429	0.1495	59.54	59.74
415	3.616	3.386	.56642E-02	.56388E-02	3.039	0.1425	0.1515	59.56	59.77
416	3.619	3.370	.56642E-02	.56388E-02	3.034	0.1422	0.1520	59.59	59.80
417	3.606	3.370	.56642E-02	.56388E-02	3.635	0.1427	0.1521	59.52	59.82
418	3.613	3.369	.56642E-02	.56388E-02	3.036	0.1425	0.1521	59.65	59.83
419	0.567	0.490	.56642E-02	.56388E-02	0.524	0.1367	0.1505	36.38	36.43
420	0.521	0.499	.56642E-02	.56388E-02	0.522	0.1420	0.1476	36.31	36.35
421	0.518	0.490	.56642E-02	.56388E-02	0.522	0.1428	0.1502	36.27	36.31
422	0.521	0.481	.56642E-02	.56388E-02	0.522	0.1418	0.1530	36.25	36.26
423	0.518	0.492	.56642E-02	.56388E-02	0.522	0.1425	0.1495	36.22	36.24
424	0.521	0.503	.56642E-02	.56388E-02	0.521	0.1417	0.1461	36.18	36.19
425	0.528	0.483	.56642E-02	.56388E-02	0.520	0.1298	0.1516	36.16	36.20
426	0.551	0.491	.56642E-02	.56388E-02	0.520	0.1336	0.1495	36.15	36.19
427	0.532	0.465	.56642E-02	.56388E-02	0.519	0.1381	0.1573	36.08	36.13
428	0.505	0.486	.56642E-02	.56388E-02	0.522	0.1464	0.1514	36.02	36.04
429	0.513	0.491	.56642E-02	.56388E-02	0.521	0.1437	0.1496	36.03	36.06
430	0.510	0.483	.56642E-02	.56388E-02	0.520	0.1445	0.1513	36.03	36.05
431	0.507	0.497	.56642E-02	.56388E-02	0.520	0.1452	0.1477	36.02	36.04
432	2.226	2.144	.56388E-02	.56896E-02	2.281	0.1444	0.1513	50.21	50.28
433	2.213	2.139	.56388E-02	.56896E-02	2.281	0.1453	0.1517	50.22	50.28
434	2.232	2.145	.56388E-02	.56896E-02	2.281	0.1441	0.1513	50.22	50.31
435	2.213	2.150	.56388E-02	.56896E-02	2.281	0.1453	0.1509	50.21	50.27
436	2.229	2.144	.56388E-02	.56896E-02	2.281	0.1443	0.1513	50.20	50.27
437	2.251	2.151	.56388E-02	.56896E-02	2.281	0.1429	0.1506	50.17	50.24
438	2.235	2.132	.56388E-02	.56896E-02	2.281	0.1438	0.1521	50.02	50.15
439	2.251	2.144	.56388E-02	.56896E-02	2.281	0.1428	0.1515	50.03	50.16
440	2.240	2.137	.56388E-02	.56896E-02	2.281	0.1432	0.1519	50.04	50.15
441	2.241	2.143	.56388E-02	.56896E-02	2.281	0.1435	0.1514	50.03	50.15
442	2.259	2.138	.56388E-02	.56896E-02	2.281	0.1424	0.1516	50.05	50.17
443	2.262	2.140	.56388E-02	.56896E-02	2.277	0.1419	0.1514	50.07	50.18
444	2.283	2.144	.56388E-02	.56896E-02	2.290	0.1414	0.1519	50.07	50.18
445	1.955	2.401	.56896E-02	.55372E-02	2.284	0.1662	0.1317	49.60	49.38
446	1.968	2.402	.56896E-02	.55372E-02	2.282	0.1649	0.1315	49.67	49.43
447	1.994	2.410	.56896E-02	.55372E-02	2.279	0.1626	0.1309	49.77	49.53
448	1.951	2.415	.56896E-02	.55372E-02	2.284	0.1635	0.1309	49.65	49.60
449	1.969	2.406	.56896E-02	.55372E-02	2.279	0.1646	0.1311	49.88	49.64
450	2.001	2.411	.56896E-02	.55372E-02	2.281	0.1621	0.1310	49.95	49.72
451	2.017	2.409	.56896E-02	.55372E-02	2.281	0.1609	0.1312	50.00	49.77
452	2.006	2.407	.56896E-02	.55372E-02	2.279	0.1616	0.1311	50.01	49.80
453	1.969	2.384	.56896E-02	.55372E-02	2.279	0.1647	0.1323	50.07	49.84
454	1.962	2.408	.56896E-02	.55372E-02	2.278	0.1651	0.1310	50.11	49.86
455	1.958	2.408	.56896E-02	.55372E-02	2.279	0.1656	0.1310	50.11	49.80
456	1.966	2.408	.56896E-02	.55372E-02	2.279	0.1649	0.1310	50.11	49.86
457	1.963	2.399	.56896E-02	.55372E-02	2.279	0.1651	0.1315	50.11	49.86
458	13.329	13.085	.19695E-01	.19713E-01	4.507	0.1865	0.1698	55.47	55.01

459	13.326	13.060	.19695E-01	.19713E-01	4.498	0.1662	0.1697	55.48	55.63
460	13.300	13.056	.19695E-01	.19713E-01	4.492	0.1663	0.1696	55.48	55.62
461	13.316	13.070	.19695E-01	.19713E-01	4.509	0.1667	0.1700	55.48	55.63
462	13.323	13.066	.19695E-01	.19713E-01	4.507	0.1666	0.1700	55.49	55.63
463	13.346	13.109	.19695E-01	.19713E-01	4.514	0.1665	0.1697	55.53	55.67
464	13.348	13.122	.19695E-01	.19713E-01	4.516	0.1667	0.1697	55.55	55.68
465	13.357	13.133	.19695E-01	.19713E-01	4.516	0.1664	0.1695	55.54	55.68
466	13.377	13.145	.19695E-01	.19713E-01	4.516	0.1662	0.1693	55.55	55.68
467	13.387	13.165	.19695E-01	.19713E-01	4.516	0.1661	0.1691	55.56	55.69
468	13.374	13.134	.19695E-01	.19713E-01	4.513	0.1662	0.1694	55.55	55.69
469	13.364	13.115	.19695E-01	.19713E-01	4.504	0.1659	0.1692	55.53	55.68
470	13.368	13.124	.19695E-01	.19713E-01	4.510	0.1661	0.1693	55.47	55.67
471	12.697	13.556	.19713E-01	.19695E-01	4.516	0.1753	0.1640	56.06	55.52
472	12.740	13.501	.19713E-01	.19695E-01	4.519	0.1748	0.1641	56.03	55.70
473	12.734	13.574	.19713E-01	.19695E-01	4.510	0.1745	0.1636	55.95	55.67
474	12.740	13.574	.19713E-01	.19695E-01	4.507	0.1743	0.1635	55.93	55.59
475	12.740	13.592	.19713E-01	.19695E-01	4.503	0.1742	0.1631	55.92	55.56
476	12.743	13.573	.19713E-01	.19695E-01	4.508	0.1743	0.1635	55.91	55.54
477	12.747	13.562	.19713E-01	.19695E-01	4.508	0.1743	0.1637	55.87	55.54
478	12.768	13.579	.19713E-01	.19695E-01	4.507	0.1740	0.1634	55.85	55.52
479	12.763	13.576	.19713E-01	.19695E-01	4.508	0.1741	0.1635	55.85	55.49
480	12.857	13.559	.19713E-01	.19695E-01	4.505	0.1727	0.1636	55.08	55.38
481	12.855	13.579	.19713E-01	.19695E-01	4.502	0.1726	0.1633	55.07	55.37
482	12.854	13.566	.19713E-01	.19695E-01	4.503	0.1720	0.1634	55.08	55.37
483	12.868	13.563	.19713E-01	.19695E-01	4.506	0.1726	0.1636	55.08	55.38
484	9.481	9.523	.19030E-01	.19080E-01	4.490	0.2256	0.2252	55.15	55.20
485	9.483	9.520	.19030E-01	.19080E-01	4.489	0.2252	0.2249	55.16	55.20
486	9.488	9.522	.19030E-01	.19080E-01	4.489	0.2251	0.2249	55.16	55.21
487	9.499	9.500	.19030E-01	.19080E-01	4.487	0.2247	0.2253	55.15	55.19
488	9.497	9.525	.19030E-01	.19080E-01	4.484	0.2247	0.2240	55.14	55.17
489	9.487	9.533	.19030E-01	.19080E-01	4.492	0.2252	0.2247	55.11	55.16
490	9.495	9.534	.19030E-01	.19080E-01	4.492	0.2251	0.2248	55.11	55.17
491	9.492	9.528	.19030E-01	.19080E-01	4.491	0.2251	0.2248	55.10	55.16
492	9.492	9.528	.19030E-01	.19080E-01	4.491	0.2251	0.2246	55.09	55.15
493	9.462	9.521	.19030E-01	.19080E-01	4.483	0.2254	0.2246	55.04	55.12
494	9.475	9.542	.19030E-01	.19080E-01	4.489	0.2254	0.2244	55.04	55.13
495	9.485	9.545	.19030E-01	.19080E-01	4.493	0.2254	0.2245	55.06	55.14
496	9.499	9.543	.19030E-01	.19080E-01	4.482	0.2245	0.2240	55.03	55.12
497	4.861	4.810	.19030E-01	.19080E-01	2.272	0.2224	0.2253	44.29	44.33
498	4.877	4.810	.19030E-01	.19080E-01	2.272	0.2216	0.2253	44.28	44.33
499	4.885	4.834	.19030E-01	.19080E-01	2.269	0.2210	0.2239	44.28	44.32
500	4.888	4.828	.19030E-01	.19080E-01	2.279	0.2218	0.2251	44.27	44.32
501	4.890	4.848	.19030E-01	.19080E-01	2.279	0.2215	0.2243	44.26	44.31
502	4.902	4.838	.19030E-01	.19080E-01	2.279	0.2212	0.2247	44.26	44.31
503	4.927	4.826	.19030E-01	.19080E-01	2.277	0.2198	0.2250	44.16	44.27
504	4.940	4.835	.19030E-01	.19080E-01	2.274	0.2190	0.2243	44.16	44.27
505	4.945	4.826	.19030E-01	.19080E-01	2.279	0.2193	0.2253	44.20	44.29
506	4.937	4.822	.19030E-01	.19080E-01	2.274	0.2192	0.2250	44.20	44.29
507	4.937	4.825	.19030E-01	.19080E-01	2.274	0.2191	0.2246	44.19	44.29
508	4.937	4.841	.19030E-01	.19080E-01	2.274	0.2191	0.2241	44.19	44.28
509	4.929	4.835	.19030E-01	.19080E-01	2.274	0.2195	0.2243	44.19	44.29
510	9.468	9.765	.19080E-01	.19030E-01	4.507	0.2260	0.2196	55.33	55.22
511	9.490	9.765	.19080E-01	.19030E-01	4.507	0.2265	0.2196	55.33	55.25
512	9.493	9.783	.19080E-01	.19030E-01	4.504	0.2263	0.2190	55.35	55.25
513	9.498	9.791	.19080E-01	.19030E-01	4.504	0.2262	0.2188	55.35	55.26
514	9.505	9.791	.19080E-01	.19030E-01	4.503	0.2259	0.2188	55.35	55.26
515	9.508	9.773	.19080E-01	.19030E-01	4.503	0.2259	0.2192	55.36	55.27
516	9.511	9.774	.19080E-01	.19030E-01	4.503	0.2258	0.2192	55.35	55.28
517	9.527	9.773	.19080E-01	.19030E-01	4.499	0.2253	0.2190	55.35	55.27
518	9.527	9.797	.19080E-01	.19030E-01	4.505	0.2256	0.2188	55.35	55.26
519	9.505	9.684	.19080E-01	.19030E-01	4.500	0.2258	0.2210	55.36	55.28
520	9.519	9.704	.19080E-01	.19030E-01	4.503	0.2256	0.2207	55.36	55.30
521	9.513	9.703	.19080E-01	.19030E-01	4.503	0.2255	0.2208	55.37	55.31
522	9.524	9.701	.19080E-01	.19030E-01	4.506	0.2257	0.2210	55.37	55.31
523	15.428	14.915	.19695E-01	.19713E-01	4.487	0.1432	0.1463	56.33	56.59
524	15.428	12.008	.19695E-01	.19713E-01	4.488	0.1432	0.1462	56.33	55.14
525	15.426	14.912	.19695E-01	.19713E-01	4.483	0.1431	0.1461	56.33	56.59
526	15.438	14.909	.19695E-01	.19713E-01	4.484	0.1430	0.1462	56.28	56.56
527	15.435	14.909	.19695E-01	.19713E-01	4.478	0.1429	0.1450	56.28	56.56
528	15.427	14.919	.19695E-01	.19713E-01	4.477	[illegible]	0.1479	56.27	56.56
529	15.467	14.913	.19695E-01	.19713E-01	4.486	0.1428	0.1462	56.27	56.55
530	15.477	14.925	.19695E-01	.19713E-01	4.465	0.1427	0.1451	56.27	56.56
531	15.483	14.923	.19695E-01	.19713E-01	4.491	0.1428	0.1483	56.27	56.56
532	15.539	14.972	.19695E-01	.19713E-01	4.493	0.1424	0.1479	56.24	56.54
533	15.547	14.950	.19695E-01	.19713E-01	4.488	0.1421	0.1460	56.24	56.55
534	15.544	14.979	.19695E-01	.19713E-01	4.488	0.1422	0.1477	56.24	56.54
535	15.542	14.963	.19695E-01	.19713E-01	4.488	0.1422	0.1478	56.24	56.54

TABLE II5 (Continued)

536	1.555	1.781	.97028E-02	.97409E-02	4.490	0.7003	0.6140	52.73	52.65
537	1.561	1.778	.97028E-02	.97409E-02	4.486	0.6973	0.6144	52.73	52.64
538	1.563	1.763	.97028E-02	.97409E-02	4.485	0.6960	0.6195	52.72	52.64
539	1.571	1.760	.97028E-02	.97409E-02	4.482	0.6920	0.6201	52.71	52.64
540	1.558	1.749	.97028E-02	.97409E-02	4.482	0.6978	0.6239	52.71	52.64
541	1.566	1.768	.97028E-02	.97409E-02	4.486	0.6950	0.6178	52.73	52.65
542	1.552	1.781	.97028E-02	.97409E-02	4.487	0.6862	0.6136	52.75	52.67
543	1.576	1.792	.97028E-02	.97409E-02	4.493	0.6914	0.6106	52.75	52.69
544	9.827	11.550	.97028E-02	.97409E-02	32.574	0.6841	0.6868	110.38	109.44
545	9.825	11.567	.97028E-02	.97409E-02	32.582	0.6843	0.6860	110.52	109.50
546	9.832	11.546	.97028E-02	.97409E-02	32.611	0.6846	0.6875	110.61	109.69
547	9.828	11.538	.97028E-02	.97409E-02	32.620	0.6851	0.6885	110.67	109.73
548	9.855	11.504	.97028E-02	.97409E-02	32.669	0.6840	0.6915	110.59	109.70
549	4.249	4.388	.11150E-01	.11200E-01	2.292	0.1504	0.1463	45.54	45.49
550	4.224	4.384	.11150E-01	.11200E-01	2.292	0.1513	0.1464	45.57	45.51
551	4.216	4.386	.11150E-01	.11200E-01	2.292	0.1516	0.1463	45.61	45.53
552	4.218	4.416	.11150E-01	.11200E-01	2.292	0.1515	0.1454	45.66	45.55
553	4.215	4.432	.11150E-01	.11200E-01	2.293	0.1516	0.1449	45.68	45.59
554	4.223	4.440	.11150E-01	.11200E-01	2.293	0.1513	0.1440	45.69	45.62
555	4.236	4.433	.11150E-01	.11200E-01	2.291	0.1507	0.1447	45.72	45.64
556	6.634	6.911	.11150E-01	.11200E-01	3.045	0.1532	0.1477	52.95	52.84
557	6.630	6.924	.11150E-01	.11200E-01	3.045	0.1531	0.1474	52.97	52.85
558	6.628	6.924	.11150E-01	.11200E-01	3.040	0.1531	0.1472	52.99	52.86
559	6.620	6.925	.11150E-01	.11200E-01	3.046	0.1535	0.1474	53.01	52.88
560	6.620	6.940	.11150E-01	.11200E-01	3.041	0.1533	0.1469	53.02	52.89
561	6.630	6.931	.11150E-01	.11200E-01	3.038	0.1529	0.1470	53.03	52.89
562	6.625	6.961	.11150E-01	.11200E-01	3.046	0.1534	0.1467	53.03	52.88
563	13.909	14.145	.12700E-01	.12700E-01	2.290	0.0523	0.0514	49.30	49.20
564	13.911	14.163	.12700E-01	.12700E-01	2.290	0.0523	0.0513	49.32	49.21
565	13.924	14.178	.12700E-01	.12700E-01	2.290	0.0522	0.0513	49.33	49.22
566	13.921	14.180	.12700E-01	.12700E-01	2.290	0.0522	0.0513	49.34	49.24
567	13.918	14.162	.12700E-01	.12700E-01	2.290	0.0522	0.0513	49.36	49.25
568	9.965	10.125	.11150E-01	.11200E-01	5.548	0.1552	0.1534	61.15	61.13
569	9.973	10.141	.11150E-01	.11200E-01	5.550	0.1551	0.1532	61.26	61.24
570	9.998	10.126	.11150E-01	.11200E-01	5.556	0.1550	0.1537	61.32	61.31
571	10.000	10.130	.11150E-01	.11200E-01	5.561	0.1550	0.1537	61.38	61.35
572	10.001	10.155	.11150E-01	.11200E-01	5.573	0.1553	0.1537	61.44	61.41
573	10.023	10.162	.11150E-01	.11200E-01	5.577	0.1551	0.1537	61.52	61.50
574	10.015	10.212	.11150E-01	.11200E-01	5.577	0.1552	0.1529	61.54	61.53
575	10.033	10.204	.11150E-01	.11200E-01	5.584	0.1552	0.1532	61.56	61.52
576	13.430	13.488	.11150E-01	.11200E-01	7.518	0.1560	0.1561	69.97	70.03
577	13.453	13.479	.11150E-01	.11200E-01	7.518	0.1558	0.1562	70.01	70.07
578	13.448	13.493	.11150E-01	.11200E-01	7.510	0.1557	0.1558	70.02	70.09
579	13.455	13.499	.11150E-01	.11200E-01	7.512	0.1556	0.1558	70.04	70.09
580	13.454	13.524	.11150E-01	.11200E-01	7.524	0.1559	0.1558	70.06	70.11
581	13.451	13.523	.11150E-01	.11200E-01	7.534	0.1561	0.1560	70.08	70.13
582	13.450	13.526	.11150E-01	.11200E-01	7.536	0.1562	0.1560	70.10	70.15
583	13.455	13.517	.11150E-01	.11200E-01	7.537	0.1561	0.1561	70.13	70.17
584	10.866	11.512	.12005E-01	.12116E-01	7.512	0.2065	0.1977	66.40	66.14
585	10.955	11.581	.12005E-01	.12116E-01	7.540	0.2076	0.1972	66.37	66.14
586	10.912	11.514	.12005E-01	.12116E-01	7.466	0.2069	0.1969	66.33	66.09
587	10.969	11.530	.12005E-01	.12116E-01	7.536	0.2075	0.1963	66.29	66.05
588	10.926	11.491	.12005E-01	.12116E-01	7.503	0.2071	0.1976	66.25	66.02
589	21.385	22.470	.12005E-01	.12116E-01	14.834	0.2099	0.2006	92.65	92.22
590	21.420	22.496	.12005E-01	.12116E-01	14.893	0.2097	0.2005	92.62	92.22
591	21.453	22.577	.12005E-01	.12116E-01	14.879	0.2092	0.1996	92.60	92.16
592	21.475	22.593	.12005E-01	.12116E-01	14.856	0.2087	0.1992	92.58	92.12
593	21.449	22.599	.12005E-01	.12116E-01	14.869	0.2091	0.1993	92.56	92.10
594	21.525	22.657	.12005E-01	.12116E-01	14.916	0.2090	0.1994	92.55	92.14
595	38.113	40.232	.12005E-01	.12116E-01	26.796	0.2121	0.2017	129.98	129.05
596	38.112	40.233	.12005E-01	.12116E-01	26.791	0.2120	0.2017	129.95	129.06
597	38.121	40.214	.12005E-01	.12116E-01	26.809	0.2121	0.2019	129.92	129.04
598	38.135	40.201	.12005E-01	.12116E-01	26.794	0.2119	0.2019	129.92	129.06
599	17.156	17.901	.12005E-01	.12116E-01	11.574	0.2035	0.1956	80.51	80.54
600	17.146	17.911	.12005E-01	.12116E-01	11.559	0.2033	0.1955	80.63	80.56
601	17.147	17.908	.12005E-01	.12116E-01	11.560	0.2034	0.1955	80.86	80.56
602	17.151	17.883	.12005E-01	.12116E-01	11.564	0.2034	0.1959	80.89	80.61
603	17.153	17.903	.12005E-01	.12116E-01	11.555	0.2042	0.1956	80.96	80.67
604	17.152	17.921	.12005E-01	.12116E-01	11.558	0.2033	0.1954	80.99	80.71
605	16.121	17.323	.12005E-01	.12116E-01	7.691	0.1419	0.1345	69.00	68.48
606	16.135	17.341	.12005E-01	.12116E-01	7.684	0.1436	0.1342	69.03	68.51
607	16.117	17.326	.12005E-01	.12116E-01	7.686	0.1438	0.1344	69.04	68.54
608	16.129	17.329	.12005E-01	.12116E-01	7.682	0.1437	0.1343	69.06	68.54
609	16.104	17.343	.12005E-01	.12116E-01	7.683	0.1439	0.1342	69.05	68.55
610	16.150	17.332	.12005E-01	.12116E-01	7.682	0.1435	0.1343	69.06	68.56
611	23.660	25.221	.12005E-01	.12116E-01	11.528	0.1470	0.1364	84.26	83.62
612	23.671	25.248	.12005E-01	.12116E-01	11.532	0.1469	0.1363	84.31	83.66

TABLE F13 (continued)

013	23.680	25.251	.12065E-01	.12116E-01	11.533	0.1469	0.1384	84.33	83.69
014	23.686	25.249	.12065E-01	.12116E-01	11.527	0.1468	0.1383	84.35	83.71
015	23.685	25.222	.12065E-01	.12116E-01	11.522	0.1467	0.1384	84.37	83.74
016	23.711	25.247	.12065E-01	.12116E-01	11.539	0.1468	0.1384	84.40	83.79
017	30.292	31.931	.12065E-01	.12116E-01	14.928	0.1486	0.1416	97.42	96.80
018	30.313	31.937	.12065E-01	.12116E-01	14.926	0.1485	0.1416	97.44	96.82
019	30.316	31.957	.12065E-01	.12116E-01	14.944	0.1487	0.1416	97.47	96.86
020	30.341	31.927	.12065E-01	.12116E-01	14.948	0.1486	0.1418	97.50	96.91
021	30.353	31.908	.12065E-01	.12116E-01	14.955	0.1486	0.1420	97.55	96.98
022	30.365	31.934	.12065E-01	.12116E-01	14.964	0.1486	0.1419	97.60	97.01
023	51.452	53.338	.12065E-01	.12116E-01	26.950	0.1580	0.1530	136.81	136.23
024	51.543	53.407	.12065E-01	.12116E-01	27.069	0.1584	0.1535	137.01	136.43
025	51.580	53.390	.12065E-01	.12116E-01	27.014	0.1580	0.1533	137.07	136.51
026	51.590	53.448	.12065E-01	.12116E-01	27.044	0.1581	0.1533	137.14	136.57
027	51.618	53.444	.12065E-01	.12116E-01	27.002	0.1578	0.1530	137.18	136.63
028	51.608	53.449	.12065E-01	.12116E-01	27.015	0.1577	0.1531	137.27	136.75
029	19.704	20.475	.12065E-01	.12116E-01	9.226	0.1412	0.1365	76.35	76.11
030	19.708	20.482	.12065E-01	.12116E-01	9.236	0.1414	0.1366	76.37	76.13
031	19.719	20.497	.12065E-01	.12116E-01	9.223	0.1411	0.1363	76.40	76.15
032	19.727	20.490	.12065E-01	.12116E-01	9.242	0.1413	0.1366	76.41	76.16
033	19.718	20.500	.12065E-01	.12116E-01	9.236	0.1413	0.1365	76.43	76.18
034	19.703	20.507	.12065E-01	.12116E-01	9.241	0.1415	0.1368	76.44	76.20
035	13.810	16.244	.12065E-01	.12116E-01	7.445	0.1626	0.1368	77.85	76.66
036	13.826	16.263	.12065E-01	.12116E-01	7.434	0.1622	0.1365	77.90	76.70
037	13.831	16.259	.12065E-01	.12116E-01	7.428	0.1620	0.1364	77.91	76.71
038	13.836	16.265	.12065E-01	.12116E-01	7.441	0.1622	0.1366	77.92	76.73
039	13.833	16.228	.12065E-01	.12116E-01	7.433	0.1621	0.1367	77.94	76.76
040	13.835	16.247	.12065E-01	.12116E-01	7.436	0.1621	0.1366	77.96	76.78
041	16.071	19.612	.12065E-01	.12116E-01	9.146	0.1655	0.1413	80.06	84.63
042	16.082	19.604	.12065E-01	.12116E-01	9.138	0.1652	0.1412	80.10	84.68
043	16.077	19.597	.12065E-01	.12116E-01	9.135	0.1652	0.1412	80.10	84.68
044	16.092	19.612	.12065E-01	.12116E-01	9.125	0.1649	0.1410	80.12	84.70
045	16.076	19.593	.12065E-01	.12116E-01	9.122	0.1650	0.1410	80.12	84.70
046	16.098	19.603	.12065E-01	.12116E-01	9.129	0.1649	0.1411	80.14	84.71
047	21.048	24.650	.12065E-01	.12116E-01	11.790	0.1690	0.1449	98.03	97.08
048	21.045	24.648	.12065E-01	.12116E-01	11.785	0.1689	0.1449	98.04	97.10
049	21.042	24.594	.12065E-01	.12116E-01	11.789	0.1690	0.1452	98.05	97.12
050	21.047	24.632	.12065E-01	.12116E-01	11.786	0.1689	0.1449	98.05	97.10
051	21.049	24.629	.12065E-01	.12116E-01	11.783	0.1688	0.1449	98.08	97.12
052	21.048	24.624	.12065E-01	.12116E-01	11.789	0.1689	0.1450	98.08	97.14
053	26.114	30.427	.12065E-01	.12116E-01	14.906	0.1722	0.1464	113.55	111.46
054	26.120	30.444	.12065E-01	.12116E-01	14.888	0.1719	0.1461	113.57	111.48
055	26.126	30.436	.12065E-01	.12116E-01	14.893	0.1719	0.1462	113.60	111.50
056	26.131	30.439	.12065E-01	.12116E-01	14.887	0.1718	0.1461	113.60	111.50
057	26.135	30.454	.12065E-01	.12116E-01	14.879	0.1717	0.1460	113.61	111.51
058	26.130	30.435	.12065E-01	.12116E-01	14.890	0.1719	0.1462	113.61	111.52
059	43.521	49.981	.12065E-01	.12116E-01	26.839	0.1860	0.1627	161.73	158.64
060	43.542	49.996	.12065E-01	.12116E-01	26.849	0.1860	0.1627	161.76	158.67
061	43.560	50.016	.12065E-01	.12116E-01	26.835	0.1858	0.1625	161.79	158.68
062	43.553	50.009	.12065E-01	.12116E-01	26.827	0.1856	0.1625	161.80	158.70
063	43.566	50.012	.12065E-01	.12116E-01	26.847	0.1859	0.1626	161.82	158.74
064	43.606	50.153	.12065E-01	.12116E-01	26.865	0.1858	0.1623	161.90	158.77
065	10.185	10.245	.11252E-01	.11252E-01	2.280	0.0631	0.0628	44.70	44.69
066	10.171	10.234	.11252E-01	.11252E-01	2.279	0.0630	0.0626	44.73	44.70
067	10.157	10.193	.11252E-01	.11252E-01	2.281	0.0632	0.0630	44.73	44.72
068	10.188	10.238	.11252E-01	.11252E-01	2.286	0.0631	0.0628	44.78	44.77
069	10.177	10.231	.11252E-01	.11252E-01	2.278	0.0630	0.0626	44.80	44.79
070	15.133	15.255	.11252E-01	.11252E-01	3.599	0.0669	0.0664	50.79	50.77
071	15.153	15.250	.11252E-01	.11252E-01	3.603	0.0669	0.0665	50.82	50.79
072	15.157	15.258	.11252E-01	.11252E-01	3.607	0.0669	0.0665	50.86	50.84
073	15.173	15.278	.11252E-01	.11252E-01	3.605	0.0668	0.0664	50.87	50.84
074	15.180	15.288	.11252E-01	.11252E-01	3.605	0.0668	0.0663	50.89	50.87
075	28.464	28.490	.11252E-01	.11252E-01	7.584	0.0749	0.0749	66.42	66.49
076	28.482	28.513	.11252E-01	.11252E-01	7.588	0.0749	0.0749	66.47	66.52
077	28.478	28.514	.11252E-01	.11252E-01	7.602	0.0751	0.0750	66.49	66.55
078	28.508	28.554	.11252E-01	.11252E-01	7.598	0.0750	0.0749	66.55	66.59
079	4.741	4.860	.11150E-01	.11200E-01	2.272	0.1336	0.1309	44.96	44.91
080	4.746	4.857	.11150E-01	.11200E-01	2.272	0.1334	0.1310	44.97	44.94
081	4.754	4.876	.11150E-01	.11200E-01	2.273	0.1332	0.1305	44.98	44.95
082	4.762	4.859	.11150E-01	.11200E-01	2.275	0.1332	0.1311	45.00	44.97
083	4.762	4.852	.11150E-01	.11200E-01	2.273	0.1330	0.1312	45.02	44.99
084	4.762	4.853	.11150E-01	.11200E-01	2.275	0.1332	0.1313	45.02	44.99
085	7.515	7.691	.11150E-01	.11200E-01	3.630	0.1346	0.1321	52.15	52.08
086	7.506	7.697	.11150E-01	.11200E-01	3.633	0.1349	0.1322	52.17	52.11
087	7.511	7.711	.11150E-01	.11200E-01	3.631	0.1347	0.1316	52.20	52.13
088	7.519	7.701	.11150E-01	.11200E-01	3.634	0.1347	0.1321	52.21	52.14
089	7.529	7.691	.11150E-01	.11200E-01	3.635	0.1346	0.1323	52.23	52.17

TABLE F13 (continued)

690	7.526	7.687	.11150E-01	.11200E-01	3.634	0.1346	0.1324	52.26	52.20
691	11.158	11.348	.11150E-01	.11200E-01	5.434	0.1358	0.1341	61.17	61.08
692	11.123	11.349	.11150E-01	.11200E-01	5.432	0.1361	0.1340	61.19	61.12
693	11.146	11.349	.11150E-01	.11200E-01	5.435	0.1359	0.1341	61.25	61.15
694	11.127	11.359	.11150E-01	.11200E-01	5.434	0.1361	0.1340	61.25	61.16
695	11.133	11.360	.11150E-01	.11200E-01	5.428	0.1359	0.1338	61.24	61.15
696	11.136	11.352	.11150E-01	.11200E-01	5.432	0.1360	0.1340	61.23	61.15
697	15.219	15.465	.11150E-01	.11200E-01	7.597	0.1392	0.1376	70.69	70.62
698	15.222	15.474	.11150E-01	.11200E-01	7.596	0.1391	0.1375	70.74	70.67
699	15.215	15.490	.11150E-01	.11200E-01	7.598	0.1392	0.1373	70.80	70.72
700	15.217	15.517	.11150E-01	.11200E-01	7.597	0.1392	0.1371	70.82	70.73
701	15.221	15.500	.11150E-01	.11200E-01	7.597	0.1391	0.1372	70.85	70.77
702	15.219	15.521	.11150E-01	.11200E-01	7.581	0.1389	0.1365	70.36	70.75
703	4.692	4.850	.19080E-01	.19050E-01	2.278	0.2316	0.2237	44.47	44.47
704	4.729	4.866	.19080E-01	.19050E-01	2.275	0.2295	0.2227	44.56	44.52
705	4.745	4.873	.19080E-01	.19050E-01	2.275	0.2287	0.2223	44.57	44.53
706	4.737	4.872	.19080E-01	.19050E-01	2.277	0.2293	0.2220	44.58	44.53
707	4.717	4.886	.19080E-01	.19050E-01	2.277	0.2302	0.2219	44.61	44.55
708	4.701	4.861	.19080E-01	.19050E-01	2.274	0.2306	0.2219	44.64	44.57
709	7.483	7.704	.19080E-01	.19050E-01	3.608	0.2300	0.2230	51.43	51.37
710	7.480	7.697	.19080E-01	.19050E-01	3.609	0.2301	0.2233	51.46	51.41
711	7.483	7.679	.19080E-01	.19050E-01	3.615	0.2304	0.2242	51.46	51.44
712	7.488	7.659	.19080E-01	.19050E-01	3.613	0.2301	0.2240	51.49	51.45
713	7.493	7.662	.19080E-01	.19050E-01	3.611	0.2298	0.2244	51.50	51.46
714	7.493	7.662	.19080E-01	.19050E-01	3.613	0.2300	0.2245	51.51	51.48
715	11.892	12.089	.19080E-01	.19050E-01	5.781	0.2319	0.2278	61.41	61.39
716	11.781	12.110	.19080E-01	.19050E-01	5.778	0.2339	0.2272	61.48	61.40
717	11.891	12.133	.19080E-01	.19050E-01	5.773	0.2316	0.2260	61.45	61.41
718	11.896	12.113	.19080E-01	.19050E-01	5.771	0.2314	0.2269	61.46	61.43
719	11.890	12.105	.19080E-01	.19050E-01	5.773	0.2316	0.2271	61.48	61.44
720	11.903	12.126	.19080E-01	.19050E-01	5.770	0.2312	0.2265	61.49	61.46
721	4.674	4.936	.19080E-01	.19050E-01	2.292	0.2340	0.2212	44.65	44.53
722	4.687	4.935	.19080E-01	.19050E-01	2.293	0.2334	0.2213	44.67	44.57
723	4.692	4.946	.19080E-01	.19050E-01	2.293	0.2331	0.2208	44.70	44.58
724	4.696	4.957	.19080E-01	.19050E-01	2.293	0.2329	0.2203	44.72	44.62
725	4.719	4.990	.19080E-01	.19050E-01	2.294	0.2319	0.2189	44.74	44.64
726	4.727	5.003	.19080E-01	.19050E-01	2.294	0.2315	0.2184	44.78	44.67
727	7.365	7.704	.19080E-01	.19050E-01	3.622	0.2340	0.2239	51.44	51.31
728	7.360	7.731	.19080E-01	.19050E-01	3.626	0.2350	0.2234	51.48	51.34
729	7.363	7.746	.19080E-01	.19050E-01	3.630	0.2352	0.2232	51.52	51.37
730	7.349	7.747	.19080E-01	.19050E-01	3.630	0.2356	0.2232	51.54	51.39
731	7.343	7.773	.19080E-01	.19050E-01	3.630	0.2358	0.2224	51.56	51.40
732	7.346	7.774	.19080E-01	.19050E-01	3.628	0.2356	0.2223	51.58	51.41
733	11.500	11.984	.19080E-01	.19050E-01	5.698	0.2363	0.2265	61.22	61.04
734	11.505	12.000	.19080E-01	.19050E-01	5.702	0.2364	0.2263	61.23	61.06
735	11.515	12.006	.19080E-01	.19050E-01	5.700	0.2361	0.2261	61.26	61.07
736	11.512	12.004	.19080E-01	.19050E-01	5.704	0.2363	0.2263	61.28	61.10
737	11.527	12.029	.19080E-01	.19050E-01	5.704	0.2360	0.2256	61.30	61.12
738	11.532	12.036	.19080E-01	.19050E-01	5.706	0.2360	0.2255	61.33	61.15

TABLE F14

THE MEAN THERMAL CONDUCTIVITIES AND STD DEVIATIONS

	TOP SPECIMEN		BOTTOM SPECIMEN	
RUNS	CONDUCTIVITY	STD DEVIATION	CONDUCTIVITY	STD DEVIATION
1-- 14	0.1934	0.00192	0.1777	0.00150
15-- 28	0.1965	0.00113	0.1765	0.00120
29-- 42	0.1942	0.01716	0.1775	0.01239
43-- 55	0.2031	0.00065	0.1730	0.00127
56-- 68	0.1825	0.00194	0.1656	0.00216
69-- 80	0.1812	0.00164	0.1946	0.00162
81-- 93	0.2053	0.00214	0.2193	0.00179
94--106	0.2010	0.00415	0.2086	0.00687
107--119	0.2030	0.00218	0.2232	0.00177
120--132	0.2195	0.00224	0.1953	0.00280
133--145	0.2053	0.00161	0.2113	0.00190
146--158	0.2035	0.00112	0.2123	0.00207
159--171	0.1779	0.00099	0.1613	0.00155
172--184	0.1765	0.00402	0.1645	0.00378
185--197	0.1818	0.00131	0.1621	0.00133
198--210	0.1741	0.00156	0.1632	0.00166
211--223	0.1763	0.00080	0.1583	0.00071
224--236	0.1761	0.00029	0.1606	0.00099
237--249	0.1734	0.00115	0.1561	0.00054
250--262	0.1650	0.00392	0.1563	0.00220
263--275	0.1760	0.00050	0.1566	0.00036
276--288	0.1714	0.00120	0.1549	0.00124
289--301	0.1568	0.00099	0.1673	0.00231
302--314	0.1595	0.00075	0.1724	0.00139
315--327	0.1509	0.00055	0.1470	0.00142
328--340	0.1444	0.00348	0.1407	0.00295
341--353	0.1518	0.00066	0.1474	0.00099
354--366	0.1421	0.00183	0.1482	0.00731
367--379	0.1422	0.00156	0.1506	0.00263
380--392	0.1439	0.00123	0.1530	0.00170
393--405	0.1426	0.00172	0.1493	0.00067
406--418	0.1433	0.00070	0.1511	0.00160
419--431	0.1402	0.00549	0.1505	0.00262
432--444	0.1435	0.00121	0.1515	0.00039
445--457	0.1642	0.00180	0.1312	0.00041

TABLE F14 (continued)

458--470	0.1663	0.00024	0.1696	0.00029
471--483	0.1739	0.00092	0.1636	0.00026
484--496	0.2251	0.00033	0.2247	0.00033
497--509	0.2203	0.00124	0.2247	0.00049
510--522	0.2259	0.00039	0.2196	0.00089
523--535	0.1427	0.00039	0.1508	0.01003
536--543	0.6947	0.00397	0.6167	0.00435
544--548	0.8044	0.00042	0.6881	0.00215
549--555	0.1512	0.00047	0.1455	0.00082
556--562	0.1532	0.00021	0.1472	0.00036
563--567	0.0522	0.00002	0.0513	0.00005
568--575	0.1551	0.00012	0.1534	0.00029
576--583	0.1559	0.00022	0.1560	0.00015
584--588	0.2075	0.00061	0.1976	0.00052
589--594	0.2093	0.00048	0.1998	0.00064
595--598	0.2120	0.00008	0.2018	0.00011
599--604	0.2033	0.00009	0.1958	0.00020
605--610	0.1437	0.00017	0.1343	0.00011
611--616	0.1469	0.00010	0.1384	0.00006
617--622	0.1486	0.00006	0.1418	0.00018
623--628	0.1580	0.00024	0.1532	0.00018
629--634	0.1413	0.00013	0.1365	0.00016
635--640	0.1622	0.00022	0.1386	0.00017
641--646	0.1651	0.00022	0.1411	0.00011
647--652	0.1689	0.00005	0.1450	0.00012
653--658	0.1719	0.00015	0.1482	0.00013
659--664	0.1859	0.00009	0.1625	0.00015
665--669	0.0631	0.00009	0.0628	0.00013
670--674	0.0669	0.00005	0.0664	0.00007
675--678	0.0750	0.00007	0.0749	0.00007
679--684	0.1333	0.00020	0.1310	0.00028
685--690	0.1347	0.00012	0.1322	0.00020
691--696	0.1360	0.00015	0.1340	0.00011
697--702	0.1391	0.00012	0.1372	0.00028
703--708	0.2300	0.00105	0.2225	0.00066
709--714	0.2301	0.00020	0.2240	0.00068
715--720	0.2319	0.00100	0.2270	0.00044
721--726	0.2326	0.00091	0.2202	0.00122
727--732	0.2352	0.00068	0.2231	0.00061
733--738	0.2362	0.00017	0.2261	0.00027

APPENDIX G

ERROR ANALYSIS

G1 PROCESS ERRORS

These are defined as errors generated by random disturbances in the process or non-steady-state error.

In all the experimental runs, the Kipps-Zonen BD5 recorder indicated that the guarded hot plate was at steady-state. As is evident from Appendix F, during a series of runs, for example, runs 1 to 14, the indicated millivolts and power input into the guarded hot plate varied. The temperatures of all the plates varied due to the varying power input. Since two stage voltage regulation was used (a.c. regulator followed by a d.c. regulator), no further improvements to the power supply circuit could be made. The process error due to electrical power supply was minimised by taking readings every hour and consequently allowing the guarded hot plate to come to new equilibrium temperatures. The thermal conductivities and conductances were evaluated at these new equilibrium temperatures.

An estimate of the process error is given by the 'probable error' of the mean of the millivolt readings. Consider for example run 549:

For thermocouple wires 1 to 9:

$$\text{mean} = 1.733\text{mV}$$

$$\text{standard deviation} = 0.001$$

$$\text{hence probable error} = \frac{0.001}{\sqrt{9}}$$

$$= 0.00033$$

$$\text{As a percentage of the mean} = 0.00033 \times 100/1.733$$

$$= \underline{0.02\%}$$

This is so small that it can be ignored.

G2 MEASUREMENT ERRORS

G2.1 PLATES

The plates were machined to within $\pm$ 0.03mm.

Considering plate 5 (11mm thick perspex), the error due to its non-flatness is estimated as:

$$\frac{0.03}{11.15} \times 100$$

$$= 0.3\%$$

For the aluminium hot and cold plates, the errors are:

$$\frac{0.03\text{mm}}{6.35\text{mm}} \times 100 = \underline{0.5\%} \text{ (for each)}$$

G2.2 TEMPERATURES

The uncertainties in the temperatures indicated by the thermocouple wires are discussed in Chapters 1 and 2. The surface temperature uncertainty (from Chapter 1) =

$$\frac{0.02^\circ C}{45.14^\circ C} \times 100$$

$$= \underline{0.04\%}$$

The calibration uncertainty (0.04°C) in indicating the temperature of run 549 for example is:

$$\frac{0.04^\circ C}{47.66^\circ C} \times 100$$

$$= \underline{0.1\%}$$

The uncertainty due to the potentiometer = $\underline{0.1\%}$.

G2.3 HEAT INPUT

The resolution of the current measuring digital multimeter is 0.005%. The voltage measuring multimeter has the same resolution too. The uncertainty in product of the voltage and the current is 0.01%.

G3 SYSTEMATIC ERRORS

The difference in the 'temperature-drops' across the specimens for any run is termed the 'systematic error' of the experiment. This is discussed in Chapter 2. Consider for example run 549:

The temperature drop across perspex plate 5 = $4.25^{\circ}C$
and the temperature drop across perspex plate 6 = $4.39^{\circ}C$

Estimate the systematic error for run 549 to be:

$$\frac{(4.39 - 4.25)}{(4.39 + 4.25)/2} \times 100 = 3\%$$

From the positioning experiments described in Chapter 2, runs II to VI use the same conditions applicable to experimental runs 1 to 738. (Run I used polystyrene insulation completely filling the stainless steel enclosure).

Using the above systematic error definition, the errors in runs II to VI (Chapter 2) were:

TABLE G1
Systematic Errors

Run	Systematic Error
II	9.5%
III	7.9%
IV	6.0%
V	3.5%
VI	3.8%

From Table G1, the systematic error chosen to take account of all the possible positionings of the apparatus in runs 1 to 738 is 10%.

G4 EXPERIMENTAL ERROR

The experimental error is the sum of the process, measurement, and systematic errors.

Sum of process errors	= 0.04%
Sum of measurement errors	= 1.8%
The systematic error	= 10%

Hence the experimental error = 12%

APPENDIX H

NUMERICAL SIMULATION RESULTS

H1 NODAL-POINT TEMPERATURES

Tables H1 to H20 show the nodal-point temperatures of the numerical simulation runs described in Table 3-6 (Chapter 3), (with the emissivity of aluminium equal to 0.04). In each case, the decimal point is not shown, for example, in run 159, the hot boundary temperature is 52.324°C in Table H1.

TABLE H1

Temperature Profile of Simulation Run 159

52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324
52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324
52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324
52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324
52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324
52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324
52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324
52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324
52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324	52324
50000	50000	50705	50000	50000	51041	51041	50000	50000	50000	50000	50000	50000	50000
50000	50000	50000	51042	51041	51071	51081	50000	50000	50000	50000	50000	50000	50000
50000	50000	50000	51042	51067	51083	51091	51097	50000	50000	50000	50000	50000	50000
50000	51046	51045	51061	51078	51089	51096	51100	51102	50000	50000	50000	50000	50000
50000	51046	51052	51067	51081	51091	51097	51100	51102	51103	50000	50000	50000	50000
50000	51086	51088	51093	51098	51101	51104	51105	51106	51106	51108	50000	50000	50000
50000	51100	51100	51102	51104	51106	51107	51107	51108	51108	51109	51109	50000	50000
50000	51103	51103	51104	51106	51107	51108	51108	51108	51108	51109	51109	51110	50000
50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000
49000	49000	49528	49000	49000	49890	49890	49000	49000	49000	49000	49000	49000	49000
49000	49000	49000	49889	49889	49887	49887	49000	49000	49000	49000	49000	49000	49000
49000	49000	49000	49889	49887	49887	49889	49890	49000	49000	49000	49000	49000	49000
49000	49887	49888	49887	49887	49888	49889	49891	49891	49000	49000	49000	49000	49000
49000	49887	49887	49886	49887	49888	49890	49891	49892	49892	49000	49000	49000	49000
49000	49887	49886	49889	49890	49891	49892	49893	49893	49894	49895	49000	49000	49000
49000	49890	49891	49891	49892	49893	49894	49894	49895	49895	49895	49896	49000	49000
49000	49891	49892	49892	49893	49894	49894	49895	49895	49895	49896	49896	49896	49000
49000	49000	49000	49000	49000	49000	49000	49000	49000	49000	49000	49000	49000	49000
48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683
48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683
48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683
48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683
48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683
48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683
48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683
48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683
48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683	48683

TABLE H2

Temperature Profile of Simulation Run 172

36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484
36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484
36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484
36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484
36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484
36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484
36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484
36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484
36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484	36484
36210	36210	36212	36210	36210	36207	36207	36210	36210	36210	36210	36210	36210	36210
36210	36210	36210	36207	36207	36210	36210	36210	36210	36210	36210	36210	36210	36210
36210	36210	36210	36207	36209	36211	36211	36212	36210	36210	36210	36210	36210	36210
36210	36207	36207	36209	36210	36211	36212	36212	36212	36210	36210	36210	36210	36210
36210	36207	36208	36209	36211	36211	36212	36212	36212	36212	36210	36210	36210	36210
36210	36211	36211	36211	36212	36212	36212	36212	36212	36212	36212	36210	36210	36210
36210	36212	36212	36212	36212	36212	36212	36212	36212	36212	36212	36212	36210	36210
36210	36212	36212	36212	36212	36212	36212	36212	36212	36212	36212	36212	36212	36210
36210	36210	36210	36210	36210	36210	36210	36210	36210	36210	36210	36210	36210	36210
35940	35940	35940	35940	35940	35945	35946	35940	35940	35940	35940	35940	35940	35940
35940	35940	35940	35946	35946	35943	35942	35940	35940	35940	35940	35940	35940	35940
35940	35940	35940	35946	35944	35942	35942	35941	35940	35940	35940	35940	35940	35940
35940	35946	35946	35944	35943	35942	35941	35941	35941	35940	35940	35940	35940	35940
35940	35946	35945	35944	35942	35942	35941	35941	35941	35941	35940	35940	35940	35940
35940	35942	35942	35942	35941	35941	35941	35941	35941	35941	35941	35940	35940	35940
35940	35941	35941	35941	35941	35941	35941	35941	35941	35941	35941	35941	35940	35940
35940	35941	35941	35941	35941	35941	35941	35941	35941	35941	35941	35941	35941	35940
35940	35940	35940	35940	35940	35940	35940	35940	35940	35940	35940	35940	35940	35940
35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669
35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669
35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669
35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669
35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669
35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669
35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669
35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669
35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669	35669

<u>TABLE H3</u>

<u>Temperature Profile of Simulation Run 186</u>

61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755
61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755
61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755
61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755
61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755
61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755
61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755
61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755
61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755	61755
59920	59920	59919	59920	59920	59872	59872	59920	59920	59920	59920	59920	59920	59920
59920	59920	59920	59874	59873	59897	59904	59920	59920	59920	59920	59920	59920	59920
59920	59920	59920	59874	59894	59906	59911	59914	59920	59920	59920	59920	59920	59920
59920	59878	59877	59890	59902	59910	59913	59915	59916	59920	59920	59920	59920	59920
59920	59878	59883	59894	59904	59911	59914	59916	59916	59917	59920	59920	59920	59920
59920	59908	59909	59912	59914	59916	59917	59918	59918	59918	59918	59920	59920	59920
59920	59916	59916	59917	59917	59918	59918	59918	59918	59918	59919	59919	59920	59920
59920	59917	59917	59918	59918	59918	59918	59918	59919	59919	59919	59919	59919	59920
59920	59920	59920	59920	59920	59920	59920	59920	59920	59920	59920	59920	59920	59920
58080	58080	58082	58080	58080	58130	58130	58080	58080	58080	58080	58080	58080	58080
58080	58080	58080	58128	58129	58105	58098	58080	58080	58080	58080	58080	58080	58080
58080	58080	58080	58128	58108	58096	58091	58088	58080	58080	58080	58080	58080	58080
58080	58125	58126	58112	58100	58092	58088	58086	58085	58080	58080	58080	58080	58080
58080	58125	58119	58108	58097	58091	58087	58086	58085	58085	58080	58080	58080	58080
58080	58094	58093	58090	58087	58085	58084	58084	58083	58083	58083	58080	58080	58080
58080	58086	58085	58085	58084	58083	58083	58083	58083	58083	58082	58082	58080	58080
58080	58084	58084	58084	58083	58083	58083	58083	58083	58083	58082	58082	58082	58080
58080	58080	58080	58080	58080	58080	58080	58080	58080	58080	58080	58080	58080	58080
56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246
56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246
56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246
56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246
56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246
56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246
56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246
56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56246
56246	56246	56246	56246	56246	56246	56246	56246	56246	56246	56245	56246	56246	56246

TABLE H4

Temperature Profile of Simulation Run 201

51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990
51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990
51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990
51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990
51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990
51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990
51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990
51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990
51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990	51990
50000	50000	50483	50000	50000	50688	50688	50000	50000	50000	50000	50000	50000	50000
50000	50000	50000	50689	50688	50713	50721	50000	50000	50000	50000	50000	50000	50000
50000	50000	50000	50689	50710	50723	50729	50734	50000	50000	50000	50000	50000	50000
50000	50692	50691	50705	50719	50728	50733	50736	50737	50000	50000	50000	50000	50000
50000	50692	50698	50710	50721	50729	50734	50736	50738	50738	50000	50000	50000	50000
50000	50725	50727	50731	50734	50737	50739	50740	50740	50741	50742	50000	50000	50000
50000	50736	50736	50738	50739	50740	50741	50741	50742	50742	50742	50743	50000	50000
50000	50738	50739	50739	50740	50741	50742	50742	50742	50742	50743	50743	50743	50000
50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000
49000	49000	49279	49000	49000	49505	49505	49000	49000	49000	49000	49000	49000	49000
49000	49000	49000	49504	49505	49497	49495	49000	49000	49000	49000	49000	49000	49000
49000	49000	49000	49504	49498	49495	49494	49494	49000	49000	49000	49000	49000	49000
49000	49502	49503	49499	49495	49494	49494	49494	49494	49000	49000	49000	49000	49000
49000	49502	49501	49497	49495	49494	49494	49494	49494	49494	49000	49000	49000	49000
49000	49494	49494	49494	49494	49494	49494	49495	49495	49495	49496	49000	49000	49000
49000	49494	49494	49494	49494	49495	49495	49495	49495	49496	49496	49496	49000	49000
49000	49494	49494	49494	49495	49495	49495	49496	49496	49496	49496	49496	49496	49000
49000	49000	49000	49000	49000	49000	49000	49000	49000	49000	49000	49000	49000	49000
48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250
48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250
48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250
48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250
48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250
48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250
48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250
48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250
48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250	48250

TABLE H5

Temperature Profile of Simulation Run 315

50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890
50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890
50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890
50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890
50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890
50890	50890	50890	50890	50890	50990	50890	50890	50890	50890	50890	50890	50890	50890
50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890
50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890
50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890	50890
50000	50000	50134	50000	50000	50158	50158	50000	50000	50000	50000	50000	50000	50000
50000	50000	50000	50158	50156	50166	50168	50000	50000	50000	50000	50000	50000	50000
50000	50000	50000	50158	50165	50168	50169	50170	50000	50000	50000	50000	50000	50000
50000	50160	50159	50164	50167	50169	50170	50170	50170	50000	50000	50000	50000	50000
50000	50160	50162	50166	50165	50169	50170	50170	50170	50170	50000	50000	50000	50000
50000	50169	50169	50169	50170	50170	50170	50170	50170	50170	50170	50000	50000	50000
50000	50170	50170	50170	50170	50170	50170	50170	50170	50170	50170	50170	50000	50000
50000	50170	50170	50170	50170	50170	50170	50170	50170	50170	50170	50170	50170	50000
50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000
49000	49000	49400	49000	49000	49451	49451	49000	49000	49000	49000	49000	49000	49000
49000	49000	49000	49451	49451	49450	49450	49000	49000	49000	49000	49000	49000	49000
49000	49000	49000	49451	49450	49450	49450	49450	49000	49000	49000	49000	49000	49000
49000	49451	49451	49450	49450	49450	49450	49450	49450	49000	49000	49000	49000	49000
49000	49451	49450	49450	49450	49450	49450	49450	49450	49451	49000	49000	49000	49000
49000	49450	49450	49450	49450	49450	49451	49451	49451	49451	49451	49000	49000	49000
49000	49450	49450	49451	49451	49451	49451	49451	49451	49451	49451	49451	49000	49000
49000	49451	49451	49451	49451	49451	49451	49451	49451	49451	49451	49451	49451	49000
49000	49000	49000	49000	49000	49000	49000	49000	49000	49000	49000	49000	49000	49000
48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731
48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731
48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731
48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731
48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731
48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731
48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731
48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731
48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731	48731

TABLE H6

Temperature Profile of Simulation Run 331

36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360
36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360
36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360
36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360
36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360
36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360
36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360
36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360
36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360	36360
36210	36210	36179	36210	36210	36177	36177	36210	36210	36210	36210	36210	36210	36210
36210	36210	36210	36177	36177	36179	36179	36210	36210	36210	36210	36210	36210	36210
36210	36210	36210	36177	36178	36179	36179	36179	36210	36210	36210	36210	36210	36210
36210	36178	36173	36178	36179	36179	36179	36179	36179	36210	36210	36210	36210	36210
36210	36178	36178	36178	36179	36179	36179	36179	36179	36179	36210	36210	36210	36210
36210	36179	36179	36179	36179	36179	36179	36179	36179	36179	36179	36210	36210	36210
36210	36179	36179	36179	36179	36179	36179	36179	36179	36179	36179	36179	36210	36210
36210	36179	36179	36179	36179	36179	36179	36179	36179	36179	36179	36179	36179	36210
36210	36210	36210	36210	36210	36210	36210	36210	36210	36210	36210	36210	36210	36210
35940	35940	35994	35940	35940	35999	35999	35940	35940	35940	35940	35940	35940	35940
35940	35940	35940	35999	35999	35998	35998	35940	35940	35940	35940	35940	35940	35940
35940	35940	35940	35999	35998	35998	35998	35998	35940	35940	35940	35940	35940	35940
35940	35999	35999	35998	35998	35998	35998	35998	35998	35940	35940	35940	35940	35940
35940	35999	35999	35998	35998	35998	35998	35998	35998	35998	35940	35940	35940	35940
35940	35998	35998	35998	35998	35998	35998	35998	35998	35998	35998	35940	35940	35940
35940	35998	35998	35998	35998	35998	35998	35998	35998	35998	35998	35998	35940	35940
35940	35998	35998	35998	35998	35998	35998	35998	35998	35998	35998	35998	35998	35940
35940	35940	35940	35940	35940	35940	35940	35940	35940	35940	35940	35940	35940	35940
35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817
35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817
35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817
35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817
35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817
35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817
35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817
35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817
35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817	35817

TABLE H7

Temperature Profile of Simulation Run 341

61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779
61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779
61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779
61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779
61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779
61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779
61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779
61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779
61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779	61779
60935	60935	60690	60935	60935	60636	60636	60935	60935	60935	60935	60935	60935	60935
60935	60935	60935	60636	60636	60643	60643	60935	60935	60935	60935	60935	60935	60935
60935	60935	60935	60636	60642	60644	60644	60644	60935	60935	60935	60935	60935	60935
60935	60639	60637	60641	60643	60644	60644	60644	60644	60935	60935	60935	60935	60935
60935	60639	60640	60643	60644	60644	60644	60644	60644	60644	60935	60935	60935	60935
60935	60644	60644	60644	60644	60644	60643	60643	60643	60643	60643	60935	60935	60935
60935	60644	60644	60644	60643	60643	60643	60643	60643	60643	60643	60643	60935	60935
60935	60643	60643	60643	60643	60643	60643	60643	60643	60643	60643	60643	60643	60935
60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935
59920	59920	59560	59920	59920	59529	59529	59920	59920	59920	59920	59920	59920	59920
59920	59920	59920	59529	59529	59515	59512	59920	59920	59920	59920	59920	59920	59920
59920	59920	59920	59529	59516	59511	59509	59509	59920	59920	59920	59920	59920	59920
59920	59525	59526	59518	59512	59510	59509	59508	59508	59920	59920	59920	59920	59920
59920	59525	59521	59515	59511	59509	59508	59508	59508	59508	59920	59920	59920	59920
59920	59510	59510	59509	59508	59508	59508	59508	59508	59508	59508	59920	59920	59920
59920	59508	59508	59508	59508	59508	59508	59508	59508	59508	59508	59508	59920	59920
59920	59508	59508	59508	59508	59508	59508	59508	59508	59508	59508	59508	59508	59920
59920	59920	59920	59920	59920	59920	59920	59920	59920	59920	59920	59920	59920	59920
58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372
58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372
58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372
58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372
58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372
58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372
58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372
58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372
58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372	58372

TABLE H8

Temperature Profile of Simulation Run 549

47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672
47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672
47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672
47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672
47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672
47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672
47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672
47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672
47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672	47672
46250	46250	46252	46250	46250	46219	46219	46250	46250	46250	46250	46250	46250	46250
46250	46250	46250	46220	46220	46237	46235	46250	46250	46250	46250	46250	46250	46250
46250	46250	46250	46220	46236	46245	46248	46250	46250	46250	46250	46250	46250	46250
46250	46221	46221	46233	46242	46247	46250	46251	46251	46250	46250	46250	46250	46250
46250	46221	46226	46236	46244	46243	46250	46251	46251	46251	46250	46250	46250	46250
46250	46240	46242	46246	46249	46250	46252	46252	46252	46252	46252	46250	46250	46250
46250	46247	46248	46249	46251	46251	46252	46252	46252	46252	46252	46252	46250	46250
46250	46249	46249	46250	46251	46252	46252	46252	46252	46252	46252	46252	46252	46250
46250	46250	46250	46250	46250	46250	46250	46250	46250	46250	46250	46250	46250	46250
44830	44830	44832	44830	44830	44867	44867	44830	44830	44830	44830	44830	44830	44830
44830	44830	44830	44865	44866	44848	44840	44830	44830	44830	44830	44830	44830	44830
44830	44830	44830	44865	44849	44841	44837	44835	44830	44830	44830	44830	44830	44830
44830	44865	44864	44853	44843	44838	44835	44834	44834	44830	44830	44830	44830	44830
44830	44865	44859	44850	44842	44837	44835	44834	44834	44834	44830	44830	44830	44830
44830	44845	44843	44840	44837	44835	44834	44833	44833	44833	44833	44830	44830	44830
44830	44838	44837	44836	44835	44834	44833	44833	44833	44833	44833	44833	44830	44830
44830	44836	44836	44835	44834	44833	44833	44833	44833	44833	44833	44833	44833	44830
44830	44830	44830	44830	44830	44830	44830	44830	44830	44830	44830	44830	44830	44830
43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413
43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413
43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413
43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413
43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413
43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413
43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413
43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413
43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413	43413

TABLE H9

Temperature Profile of Simulation Run 556

56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270
56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270
56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270
56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270
56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270
56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270
56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270
56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270
56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270	56270
52000	52000	53436	52000	52000	53937	53937	52000	52000	52000	52000	52000	52000	52000
52000	52000	52000	53940	53940	53994	54022	52000	52000	52000	52000	52000	52000	52000
52000	52000	52000	53940	53990	54020	54035	54043	52000	52000	52000	52000	52000	52000
52000	53940	53942	53977	54010	54030	54041	54047	54050	52000	52000	52000	52000	52000
52000	53940	53957	53987	54015	54033	54043	54048	54051	54051	52000	52000	52000	52000
52000	54001	54008	54021	54035	54044	54050	54053	54054	54055	54056	52000	52000	52000
52000	54026	54029	54037	54044	54050	54053	54055	54056	54056	54057	54058	52000	52000
52000	54033	54036	54041	54047	54051	54054	54056	54056	54056	54058	54058	54059	52000
52000	52000	52000	52000	52000	52000	52000	52000	52000	52000	52000	52000	52000	52000
50000	50000	51254	50000	50000	51843	51843	50000	50000	50000	50000	50000	50000	50000
50000	50000	50000	51842	51843	51837	51838	50000	50000	50000	50000	50000	50000	50000
50000	50000	50000	51842	51837	51838	51841	51843	50000	50000	50000	50000	50000	50000
50000	51840	51841	51837	51837	51839	51842	51844	51845	50000	50000	50000	50000	50000
50000	51840	51838	51836	51837	51840	51842	51844	51845	51846	50000	50000	50000	50000
50000	51834	51835	51837	51839	51842	51845	51846	51847	51847	51848	50000	50000	50000
50000	51836	51836	51839	51842	51844	51846	51847	51848	51846	51849	51850	50000	50000
50000	51837	51837	51840	51843	51845	51847	51848	51848	51849	51849	51650	51850	50000
50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000
49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644
49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644
49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644
49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644
49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644
49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644
49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644
49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644
49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644	49644

TABLE H10

Temperature Profile of Simulation Run 568

66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200
66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200
66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200
66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200
66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200
66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200
66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200
66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200
66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200	66200
62795	62795	62564	62547	62547	62741	62741	62300	62200	62100	62000	61900	61800	62800
62795	61700	59978	62691	62739	62791	62813	61100	61000	60900	60500	60700	60600	62800
62795	60500	59978	62691	62779	62810	62821	62826	59820	59700	59600	59630	59500	62800
62795	62734	62695	62743	62797	62817	62825	62828	62830	56600	58500	56400	58300	62800
62795	62734	62717	62757	62801	62819	62826	62829	62830	62630	57900	56110	56230	62800
62800	62789	62786	62800	62817	62826	62829	62831	62832	62832	62832	56490	59640	62800
62800	62811	62811	62817	62825	62829	62831	62832	62832	62832	62833	62833	64700	62800
62800	62817	62817	62821	62827	62830	62831	62832	62832	62832	62833	62833	62833	62000
62800	62770	65800	65700	65200	60680	65300	65010	64230	65140	65800	64600	64900	62800
59589	59589	59507	60154	60154	59574	59574	60180	60200	60220	60250	60260	60270	59400
59589	60300	60536	59506	59560	59516	59490	60410	60420	60430	60440	60450	60460	59400
59589	60470	60536	59568	59517	59491	59480	59474	60700	60800	60900	61120	61130	59400
59589	59553	59560	59525	59497	59483	59475	59472	59470	60570	60500	60600	56120	59400
59589	59553	59543	59515	59492	59480	59474	59471	59470	59469	56250	56260	56270	59400
59400	59498	59494	59484	59477	59472	59470	59469	59468	59468	59467	56410	56420	59400
59400	59478	59476	59473	59470	59469	59468	59468	59467	59467	59467	59467	59700	59400
59400	59473	59472	59470	59469	59468	59468	59467	59467	59467	59467	59467	59467	59400
59400	59660	59880	59900	59310	56640	56550	56740	56300	56400	56200	55100	55400	59400
56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100
56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100
56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100
56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100
56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100
56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100
56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100
56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100
56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100	56100

TABLE H11

Temperature Profile of Simulation Run 576

76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680
76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680
76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680
76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680
76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680
76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680
76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680
76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680
76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680	76680
71689	71689	71961	71689	71689	72054	72054	71689	71689	71689	71689	71689	71689	71689
71689	71689	71689	72059	72058	72131	72165	71689	71689	71689	71689	71689	71689	71689
71689	71689	71689	72059	72126	72173	72181	72189	71689	71689	71689	71689	71689	71689
71689	72061	72062	72110	72152	72175	72187	72193	72195	71689	71689	71689	71689	71689
71689	72061	72083	72123	72159	72179	72189	72194	72196	72197	71689	71689	71689	71689
71689	72142	72151	72167	72181	72190	72195	72198	72199	72199	72200	71689	71689	71689
71689	72173	72177	72184	72191	72196	72198	72200	72200	72201	72201	72202	71689	71689
71689	72181	72184	72189	72193	72197	72199	72200	72201	72201	72202	72202	72202	71689
71689	71689	71689	71689	71689	71689	71689	71689	71689	71689	71689	71689	71689	71689
66312	66312	67366	66312	66312	67819	67819	66312	66312	66312	66312	66312	66312	66312
66312	66312	66312	67815	67816	67763	67742	66312	66312	66312	66312	66312	66312	66312
66312	66312	66312	67815	67707	67743	67734	67720	66312	66312	66312	66312	66312	66312
66312	67812	67811	67773	67749	67736	67730	67728	67727	66312	66312	66312	66312	66312
66312	67812	67796	67768	67745	67734	67730	67728	67727	67727	66312	66312	66312	66312
66312	67754	67749	67740	67732	67729	67727	67727	67726	67726	67726	66312	66312	66312
66312	67735	67733	67730	67728	67727	67726	67726	67726	67726	67726	67726	66312	66312
66312	67730	67729	67728	67727	67726	67726	67726	67726	67726	67726	67726	67726	66312
66312	66312	66312	66312	66312	66312	66312	66312	66312	66312	66312	66312	66312	66312
63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251
63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251
63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251
63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251
63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251
63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251
63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251
63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251
63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251	63251

TABLE H12

Temperature Profile of Simulation Run 605

77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066
77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066
77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066
77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066
77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066
77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066
77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066
77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066
77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066	77066
71689	71689	71689	71689	71689	71531	71531	71689	71689	71689	71689	71689	71689	71689
71689	71689	71689	71537	71535	71613	71651	71689	71689	71689	71689	71689	71689	71689
71689	71689	71689	71537	71608	71649	71667	71676	71689	71689	71689	71689	71689	71689
71689	71541	71542	71592	71635	71661	71674	71680	71683	71689	71689	71689	71689	71689
71689	71541	71565	71606	71643	71665	71676	71681	71683	71684	71689	71689	71689	71689
71689	71631	71640	71655	71669	71676	71683	71685	71686	71687	71686	71689	71689	71689
71689	71664	71668	71674	71680	71684	71686	71687	71688	71688	71686	71689	71689	71689
71689	71673	71675	71679	71683	71685	71687	71688	71688	71688	71689	71689	71689	71689
71689	71689	71689	71689	71689	71689	71689	71689	71689	71689	71689	71689	71689	71689
66312	66312	66312	66312	66312	66486	66466	66312	66312	66312	66312	66312	66312	66312
66312	66312	66312	66480	66482	66399	66357	66312	66312	66312	66312	66312	66312	66312
66312	66312	66312	66480	66405	66360	66339	66325	66312	66312	66312	66312	66312	66312
66312	66476	66475	66422	66375	66348	66331	66324	66321	66312	66312	66312	66312	66312
66312	66476	66451	66407	66367	66342	66329	66323	66320	66320	66312	66312	66312	66312
66312	66380	66371	66353	66337	66327	66321	66318	66317	66316	66315	66312	66312	66312
66312	66343	66340	66332	66325	66320	66317	66316	66315	66315	66314	66313	66312	66312
66312	66334	66332	66327	66322	66318	66316	66315	66314	66314	66313	66313	66313	66312
66312	66312	66312	66312	66312	66312	66312	66312	66312	66312	66312	66312	66312	66312
60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935
60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935
60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935
60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935
60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935
60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935
60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935
60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935
60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935	60935

TABLE H13

Temperature Profile of Simulation Run 611

96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090
96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090
96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090
96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090
96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090
96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090
96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090
96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090
96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090	96090
88205	88205	88205	88205	88205	87951	87951	88205	88205	88205	88205	88205	88205	88205
88205	88205	88205	87960	87957	88083	88144	88205	88205	88205	88205	88205	88205	88205
88205	88205	88205	87960	88074	88141	88171	88185	88205	88205	88205	88205	88205	88205
88205	87967	87968	88049	88119	88161	88182	88191	88195	88205	88205	88205	88205	88205
88205	87967	88005	88072	88131	88167	88184	88193	88196	88197	88205	88205	88205	88205
88205	88113	88126	88151	88174	88188	88196	88199	88201	88201	88203	88205	88205	88205
88205	88166	88171	88182	88191	88197	88201	88202	88203	88203	88204	88205	88205	88205
88205	88160	88183	88189	88196	88200	88202	88203	88204	88204	88204	88205	88205	88205
88205	88205	88205	88205	88205	88205	88205	88205	88205	88205	88205	88205	88205	88205
80319	80319	80319	80319	80319	80612	80612	80319	80319	80319	80319	80319	80319	80319
80319	80319	80319	80602	80605	80456	80397	80319	80319	80319	80319	80319	80319	80319
80319	80319	80319	80602	80476	80401	80366	80348	80319	80319	80319	80319	80319	80319
80319	80596	80594	80505	80426	80377	80353	80341	80336	80319	80319	80319	80319	80319
80319	80596	80554	80479	80412	80370	80349	80339	80334	80333	80319	80319	80319	80319
80319	80434	80419	80390	80363	80345	80335	80330	80328	80327	80324	80319	80319	80319
80319	80373	80367	80354	80342	80333	80328	80326	80325	80324	80322	80322	80319	80319
80319	80358	80354	80345	80336	80330	80327	80325	80324	80324	80322	80321	80321	80319
80319	80319	80319	80319	80319	80319	80319	80319	80319	80319	80319	80319	80319	80319
72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434
72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434
72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434
72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434
72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434
72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434
72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434
72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434
72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434	72434

TABLE H14

Temperature Profile of Simulation Run 617

11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257
11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257
11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257
11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257
11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257
11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257
11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257
11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257
11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257	11257
10247	10247	10247	10247	10247	10212	10212	10247	10247	10247	10247	10247	10247	10247
10247	10247	10247	10213	10212	10230	10239	10247	10247	10247	10247	10247	10247	10247
10247	10247	10247	10213	10229	10238	10242	10244	10247	10247	10247	10247	10247	10247
10247	10214	10214	10225	10235	10241	10244	10245	10246	10247	10247	10247	10247	10247
10247	10214	10219	10229	10237	10242	10244	10245	10246	10246	10247	10247	10247	10247
10247	10234	10236	10240	10243	10245	10246	10246	10246	10246	10247	10247	10247	10247
10247	10242	10242	10244	10245	10246	10246	10246	10247	10247	10247	10247	10247	10247
10247	10243	10244	10245	10246	10246	10246	10247	10247	10247	10247	10247	10247	10247
10247	10247	10247	10247	10247	10247	10247	10247	10247	10247	10247	10247	10247	10247
9237	9237	9237	9237	9237	9278	9278	9237	9237	9237	9237	9237	9237	9237
9237	9237	9237	9277	9273	9258	9248	9237	9237	9237	9237	9237	9237	9237
9237	9237	9237	9277	9259	9246	9243	9241	9237	9237	9237	9237	9237	9237
9237	9276	9276	9263	9252	9245	9241	9240	9239	9237	9237	9237	9237	9237
9237	9276	9270	9260	9250	9244	9241	9239	9239	9239	9237	9237	9237	9237
9237	9253	9251	9247	9243	9240	9239	9238	9238	9238	9237	9237	9237	9237
9237	9244	9244	9242	9240	9239	9238	9238	9237	9237	9237	9237	9237	9237
9237	9242	9242	9240	9239	9238	9238	9237	9237	9237	9237	9237	9237	9237
9237	9237	9237	9237	9237	9237	9237	9237	9237	9237	9237	9237	9237	9237
8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226
8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226
8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226
8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226
8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226
8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226
8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226
8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226
8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226	8226

TABLE H15

Temperature Profile of Simulation Run 624

16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277
16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277
16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277
16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277
16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277
16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277
16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277
16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277
16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277	16277
14559	14559	14559	14559	14559	14485	14485	14559	14559	14559	14559	14559	14559	14559
14559	14559	14559	14488	14487	14525	14543	14559	14559	14559	14559	14559	14559	14559
14559	14559	14559	14488	14522	14542	14550	14554	14559	14559	14559	14559	14559	14559
14559	14490	14491	14515	14536	14548	14553	14556	14557	14559	14559	14559	14559	14559
14559	14490	14502	14522	14539	14549	14554	14556	14557	14558	14559	14559	14559	14559
14559	14534	14538	14545	14551	14555	14557	14558	14559	14559	14559	14559	14559	14559
14559	14549	14551	14554	14556	14558	14559	14559	14559	14559	14559	14559	14559	14559
14559	14553	14554	14555	14557	14558	14559	14559	14559	14559	14559	14559	14559	14559
14559	14559	14559	14559	14559	14559	14559	14559	14559	14559	14559	14559	14559	14559
12841	12841	12841	12841	12841	12938	12938	12841	12841	12841	12841	12841	12841	12841
12841	12841	12841	12935	12936	12890	12868	12841	12841	12841	12841	12841	12841	12841
12841	12841	12841	12935	12894	12869	12857	12851	12841	12841	12841	12841	12841	12841
12841	12933	12932	12903	12877	12861	12853	12849	12847	12841	12841	12841	12841	12841
12841	12933	12919	12895	12873	12859	12852	12848	12847	12846	12841	12841	12841	12841
12841	12860	12875	12866	12856	12850	12847	12845	12844	12844	12843	12841	12841	12841
12841	12860	12858	12854	12849	12846	12845	12844	12843	12843	12842	12842	12841	12841
12841	12855	12854	12851	12848	12845	12844	12843	12843	12843	12842	12842	12842	12841
12841	12841	12841	12841	12841	12841	12841	12841	12841	12841	12841	12841	12841	12841
11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123
11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123
11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123
11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123
11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123
11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123
11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123
11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123
11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123	11123

TABLE H16

Temperature Profile of Simulation Run 629

86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207
86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207
86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207
86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207
86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207
86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207
86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207
86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207
86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207	86207
79641	79641	79641	79641	79641	79639	79639	79641	79641	79641	79641	79641	79641	79641
79641	79641	79641	79447	79444	79544	79593	79641	79641	79641	79641	79641	79641	79641
79641	79641	79641	79447	79537	79590	79614	79625	79641	79641	79641	79641	79641	79641
79641	79452	79453	79517	79573	79606	79622	79630	79633	79641	79641	79641	79641	79641
79641	79452	79482	79535	79582	79611	79625	79631	79634	79635	79641	79641	79641	79641
79641	79568	79578	79598	79616	79628	79634	79637	79638	79638	79640	79641	79641	79641
79641	79610	79614	79622	79630	79635	79638	79639	79640	79640	79640	79641	79641	79641
79641	79621	79623	79628	79633	79637	79639	79640	79640	79640	79641	79641	79641	79641
79641	79641	79641	79641	79641	79641	79641	79641	79641	79641	79641	79641	79641	79641
73075	73075	73075	73075	73075	73302	73302	73075	73075	73075	73075	73075	73075	73075
73075	73075	73075	73294	73297	73188	73135	73075	73075	73075	73075	73075	73075	73075
73075	73075	73075	73294	73196	73138	73111	73097	73075	73075	73075	73075	73075	73075
73075	73289	73288	73219	73157	73119	73101	73091	73087	73075	73075	73075	73075	73075
73075	73289	73257	73199	73147	73114	73098	73090	73086	73065	73075	73075	73075	73075
73075	73164	73152	73129	73108	73094	73087	73083	73081	73081	73078	73075	73075	73075
73075	73116	73112	73102	73092	73086	73082	73080	73079	73079	73077	73077	73075	73075
73075	73104	73101	73095	73088	73063	73060	73079	73078	73078	73077	73076	73070	73075
73075	73075	73075	73075	73075	73075	73075	73075	73075	73075	73075	73075	73075	73075
66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509
66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509
66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509
66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509
66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509
66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509
66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509
66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509
66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509	66509

TABLE H17

Temperature Profile of Simulation Run 679

47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335
47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335
47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335
47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335
47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335
47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335
47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335
47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335
47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335	47335
46250	46250	45692	46250	46250	45732	45752	46250	46250	46250	46250	46250	46250	46250
46250	46250	46250	45732	45733	45747	45752	46250	46250	46250	46250	46250	46250	46250
46250	46250	46250	45732	45747	45752	45753	45754	46250	46250	46250	46250	46250	46250
46250	45733	45734	45743	45751	45753	45754	45754	45754	46250	46250	46250	46250	46250
46250	45733	45739	45746	45752	45754	45754	45754	45754	45754	46250	46250	46250	46250
46250	45745	45747	45751	45753	45754	45754	45754	45753	45753	45753	46250	46250	46250
46250	45750	45751	45753	45754	45754	45754	45754	45753	45753	45753	45753	46250	46250
46250	45752	45753	45754	45754	45754	45754	45754	45753	45753	45753	45753	45753	46250
46250	46250	46250	46250	46250	46250	46250	46250	46250	46250	46250	46250	46250	46250
44830	44830	44325	44830	44830	44224	44224	44830	44830	44830	44830	44830	44830	44830
44830	44830	44830	44229	44222	44195	44182	44830	44830	44830	44830	44830	44830	44830
44830	44830	44830	44229	44196	44184	44177	44174	44830	44830	44830	44830	44830	44830
44830	44230	44227	44208	44188	44180	44175	44173	44173	44830	44830	44830	44830	44830
44830	44230	44219	44203	44186	44179	44175	44173	44172	44172	44830	44830	44830	44830
44830	44209	44203	44193	44182	44176	44174	44172	44172	44171	44171	44830	44830	44830
44830	44199	44195	44187	44179	44175	44173	44172	44171	44171	44171	44171	44830	44830
44830	44196	44192	44185	44179	44175	44173	44172	44171	44171	44171	44171	44171	44830
44830	44830	44830	44830	44830	44830	44830	44830	44830	44830	44830	44830	44830	44830
42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586
42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586
42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586
42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586
42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586
42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586
42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586
42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586
42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586	42586

TABLE H18

Temperature Profile of Simulation Run 686

55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938
55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938
55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938
55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938
55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938
55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938
55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938
55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938
55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938	55938
50000	50000	52670	50000	50000	53281	53261	50000	50000	50000	50000	50000	50000	50000
50000	50000	50000	53265	53286	53356	53390	50000	50000	50000	50000	50000	50000	50000
50000	50000	50000	53265	53353	53386	53404	53413	50000	50000	50000	50000	50000	50000
50000	53261	53289	53318	53373	53397	53410	53416	53418	50000	50000	50000	50000	50000
50000	53261	53289	53331	53378	53400	53411	53417	53419	53419	50000	50000	50000	50000
50000	53313	53329	53358	53390	53406	53415	53419	53422	53422	53424	50000	50000	50000
50000	53339	53351	53373	53396	53410	53417	53421	53423	53423	53424	53425	50000	50000
50000	53347	53357	53377	53398	53411	53418	53421	53423	53423	53424	53425	53425	50000
50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000
49000	49000	50318	49000	49000	50919	50919	49000	49000	49000	49000	49000	49000	49000
49000	49000	49000	50913	50918	50909	50909	49000	49000	49000	49000	49000	49000	49000
49000	49000	49000	50913	50907	50908	50912	50914	49000	49000	49000	49000	49000	49000
49000	50909	50909	50904	50906	50909	50913	50915	50916	49000	49000	49000	49000	49000
49000	50909	50905	50902	50905	50910	50913	50915	50916	50916	49000	49000	49000	49000
49000	50898	50898	50900	50906	50911	50914	50916	50918	50918	50919	49000	49000	49000
49000	50894	50895	50899	50906	50911	50915	50917	50918	50918	50919	50919	49000	49000
49000	50893	50895	50899	50906	50912	50915	50917	50918	50918	50919	50920	50920	49000
49000	49000	49000	49000	49000	49000	49000	49000	49000	49000	49000	49000	49000	49000
48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419
48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419
48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419
48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419
48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419
48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419
48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419
48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419
48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419	48419

TABLE H19

Temperature Profile of Simulation Run 692

66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764
66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764
66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764
66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764
66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764
66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764
66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764
66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764
66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764	66764
59920	59920	62395	59920	59920	62878	62878	59920	59920	59920	59920	59920	59920	59920
59920	59920	59920	62861	62884	62970	63009	59920	59920	59920	59920	59920	59920	59920
59920	59920	59920	62861	62907	63005	63025	63034	59920	59920	59920	59920	59920	59920
59920	62859	62868	62927	62991	63018	63032	63038	63041	59920	59920	59920	59920	59920
59920	62859	62893	62943	62997	63021	63033	63039	63041	63041	59920	59920	59920	59920
59920	62923	62943	62976	63011	63028	63037	63042	63044	63044	63046	59920	59920	59920
59920	62955	62969	62993	63018	63032	63039	63043	63045	63045	63046	63047	59920	59920
59920	62965	62977	62998	63020	63033	63040	63043	63045	63045	63046	63047	63047	59920
59920	59920	59920	59920	59920	59920	59920	59920	59920	59920	59920	59920	59920	59920
58080	58080	58876	58080	58080	59390	59390	58080	58080	58080	58080	58080	58080	58080
58080	58080	58080	59389	59387	59350	59338	58080	58080	58080	58080	58080	58080	58080
58080	58080	58080	59389	59349	59338	59335	59335	58080	58080	58080	58080	58080	58080
58080	59364	59383	59358	59340	59335	59335	59335	59335	58080	58080	58080	58080	58080
58080	59364	59370	59351	59338	59335	59335	59335	59335	59335	58080	58080	58080	58080
58080	59353	59347	59338	59334	59333	59334	59336	59336	59336	59336	58080	58080	58080
58080	59339	59336	59333	59332	59333	59334	59336	59336	59336	59337	59337	58080	58080
58080	59335	59333	59331	59331	59333	59335	59336	59336	59336	59337	59337	59337	58080
58080	58080	58080	58080	58080	58080	58080	58080	58080	58080	58080	58080	58080	58080
55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630
55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630
55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630
55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630
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55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630
55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630
55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630
55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630	55630

TABLE H20

Temperature Profile of Simulation Run 698

78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359
78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359
78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359
78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359
78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359
78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359
78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359
78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359
78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359	78359
71689	71689	72854	71689	71689	73097	73097	71689	71689	71689	71689	71689	71689	71689
71689	71689	71689	73081	73104	73200	73242	71689	71689	71689	71689	71689	71689	71689
71689	71689	71689	73081	73197	73238	73259	73268	71689	71689	71689	71689	71689	71689
71689	73080	73089	73154	73223	73251	73255	73271	73274	71689	71689	71689	71689	71689
71689	73080	73117	73172	73229	73254	73267	73272	73274	73275	71689	71689	71689	71689
71689	73152	73173	73208	73244	73262	73271	73275	73277	73277	73278	71689	71689	71689
71689	73188	73202	73227	73252	73266	73273	73276	73278	73278	73279	73280	71689	71689
71689	73199	73211	73233	73255	73267	73273	73277	73278	73278	73279	73280	73280	71689
71689	71689	71689	71689	71689	71689	71689	71689	71689	71689	71689	71689	71689	71689
60312	60312	67748	60312	60312	68303	68303	60312	60312	60312	60312	60312	60312	60312
60312	60312	60312	68307	68299	68239	68218	60312	60312	60312	60312	60312	60312	60312
60312	60312	60312	68307	68240	68219	68211	68208	60312	60312	60312	60312	60312	60312
60312	68303	68299	68259	68224	68213	68208	68207	68207	60312	60312	60312	60312	60312
60312	68303	68280	68248	68221	68211	68208	68207	68207	68207	60312	60312	60312	60312
60312	68255	68243	68227	68213	68208	68207	68207	68206	68207	68207	60312	60312	60312
60312	68233	68225	68216	68209	68207	68206	68206	68206	68207	68207	68207	60312	60312
60312	68226	68221	68213	68208	68206	68206	68206	68206	68207	68207	68207	68207	60312
60312	60312	60312	60312	60312	60312	60312	60312	60312	60312	60312	60312	60312	60312
63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135
63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135
63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135
63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135
63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135
63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135
63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135
63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135
63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135	63135

H2 HEAT FLUX PROFILE

Table H21 shows the heat flows between nodal points (results of run 568A - 11mm thick perspex with the aluminium emissivity equal to 0.04).

Tables H23 and H24 show the corresponding radiation flows.

Table H22 shows the values of dQ_r/dT for the surface points.

TABLE H21 - Heat Flows (W) - Run 568A

PT NO	QYX(K)	QYX(K+126)	QXY(K-1)	QXY(K)	QZX(K-14)	QZX(K)	TOTAL HEAT FLOW	% ERROR
146	-.8679E-03	-.8337E-03	-.2716E-04	-.1424E-04	-.4029E-04	-.1897E-04	.5439E-06	0.001
	HEAT INTO POINT= -.901114E-03			HEAT CONDUCTED AWAY FROM POINT= -.901120E-03				
147	-.3387E-03	-.3322E-03	-.1424E-04	0.	0.	-.7720E-05	.3521E-06	0.001
	HEAT INTO POINT= -.346437E-03			HEAT CONDUCTED AWAY FROM POINT= -.346440E-03				
159	-.7049E-03	-.6724E-03	-.2830E-04	-.1111E-04	-.5231E-04	-.3701E-04	.6010E-06	0.001
	HEAT INTO POINT= -.753036E-03			HEAT CONDUCTED AWAY FROM POINT= -.753044E-03				
160	-.5943E-03	-.5818E-03	-.1111E-04	-.5127E-05	-.1697E-04	-.1246E-04	.7620E-06	0.001
	HEAT INTO POINT= -.611886E-03			HEAT CONDUCTED AWAY FROM POINT= -.611893E-03				
161	-.4653E-03	-.4603E-03	-.5127E-05	-.2924E-05	-.7720E-05	-.4895E-05	.8535E-06	0.002
	HEAT INTO POINT= -.473116E-03			HEAT CONDUCTED AWAY FROM POINT= -.473125E-03				
162	-.1600E-03	-.1590E-03	-.2924E-05	0.	0.	-.1920E-05	.4619E-06	0.003
	HEAT INTO POINT= -.161903E-03			HEAT CONDUCTED AWAY FROM POINT= -.161907E-03				
172	-.4035E-03	-.3757E-03	-.7328E-05	-.6743E-05	-.1234E-03	-.9409E-04	.1091E-07	0.002
	HEAT INTO POINT= -.506353E-03			HEAT CONDUCTED AWAY FROM POINT= -.506364E-03				
173	-.5124E-03	-.4969E-03	-.8743E-05	-.3696E-05	-.3701E-04	-.2656E-04	.1423E-07	0.003
	HEAT INTO POINT= -.542686E-03			HEAT CONDUCTED AWAY FROM POINT= -.542700E-03				
174	-.3024E-03	-.2980E-03	-.3696E-05	-.1826E-05	-.1248E-04	-.1001E-04	.1685E-07	0.005
	HEAT INTO POINT= -.314173E-03			HEAT CONDUCTED AWAY FROM POINT= -.314190E-03				
175	-.2370E-03	-.2352E-03	-.1826E-05	-.1035E-05	-.4695E-05	-.3926E-05	.1755E-07	0.007
	HEAT INTO POINT= -.241925E-03			HEAT CONDUCTED AWAY FROM POINT= -.241943E-03				
176	-.1630E-03	-.1623E-03	-.1035E-05	-.6886E-06	-.1920E-05	-.1559E-05	.1549E-07	0.009
	HEAT INTO POINT= -.165256E-03			HEAT CONDUCTED AWAY FROM POINT= -.165273E-03				
177	-.4155E-04	-.4142E-04	-.6886E-06	0.	0.	-.5643E-06	.6991E-08	0.017
	HEAT INTO POINT= -.421073E-04			HEAT CONDUCTED AWAY FROM POINT= -.421143E-04				
185	-.7567E-03	-.6895E-03	.4278E-05	-.1045E-04	-.1668E-03	-.8494E-04	-.4182E-09	-0.000
	HEAT INTO POINT= -.852057E-03			HEAT CONDUCTED AWAY FROM POINT= -.852057E-03				
186	-.7045E-03	-.6633E-03	-.1045E-04	-.1267E-04	-.9409E-04	-.5067E-04	-.8313E-09	-0.000

TABLE H21 (continued)

HEAT INTO POINT= -.767866E-03 HEAT CONDUCTED AWAY FROM POINT= -.767867E-03

187	-.6259E-03	-.6093E-03	-.1267E-04	-.5706E-05	-.2656E-04	-.1697E-04	-.8112E-09	-0.000	HEAT INTO POINT= -.648570E-03	HEAT CONDUCTED AWAY FROM POINT= -.648569E-03
188	-.5297E-03	-.5230E-03	-.5706E-05	-.2826E-05	-.1001E-04	-.6201E-05	-.5404E-09	-0.000	HEAT INTO POINT= -.538696E-03	HEAT CONDUCTED AWAY FROM POINT= -.538695E-03
189	-.4152E-03	-.4125E-03	-.2826E-05	-.1602E-05	-.3926E-05	-.2411E-05	.3252E-09	0.000	HEAT INTO POINT= -.419257E-03	HEAT CONDUCTED AWAY FROM POINT= -.419257E-03
190	-.2857E-03	-.2846E-03	-.1602E-05	-.1071E-05	-.1559E-05	-.9696E-06	.2341E-08	0.001	HEAT INTO POINT= -.287752E-03	HEAT CONDUCTED AWAY FROM POINT= -.287755E-03
191	-.1456E-03	-.1452E-03	-.1071E-05	-.8810E-06	-.5643E-06	-.3563E-06	.1063E-07	0.007	HEAT INTO POINT= -.146835E-03	HEAT CONDUCTED AWAY FROM POINT= -.146846E-03
192	-.1276E-03	-.1273E-03	-.8810E-06	0.	0.	-.5616E-06	-.1560E-08	-0.001	HEAT INTO POINT= -.128153E-03	HEAT CONDUCTED AWAY FROM POINT= -.128152E-03
198	-.6467E-03	-.6241E-03	0.	.1607E-05	-.3496E-04	-.1395E-04	.7074E-09	0.000	HEAT INTO POINT= -.659041E-03	HEAT CONDUCTED AWAY FROM POINT= -.659042E-03
199	-.1270E-02	-.1224E-02	.1607E-05	-.6580E-05	-.8494E-04	-.3126E-04	.1306E-08	0.000	HEAT INTO POINT= -.130777E-02	HEAT CONDUCTED AWAY FROM POINT= -.130777E-02
200	-.1191E-02	-.1162E-02	-.6580E-05	-.8370E-05	-.5067E-04	-.1960E-04	.1916E-08	0.000	HEAT INTO POINT= -.121894E-02	HEAT CONDUCTED AWAY FROM POINT= -.121895E-02
201	-.1066E-02	-.1053E-02	-.8370E-05	-.4632E-05	-.1697E-04	-.7535E-05	.2781E-08	0.000	HEAT INTO POINT= -.107860E-02	HEAT CONDUCTED AWAY FROM POINT= -.107860E-02
202	-.9049E-03	-.8994E-03	-.4632E-05	-.2458E-05	-.6201E-05	-.2801E-05	.3847E-08	0.000	HEAT INTO POINT= -.910184E-03	HEAT CONDUCTED AWAY FROM POINT= -.910188E-03
203	-.7100E-03	-.7077E-03	-.2458E-05	-.1437E-05	-.2411E-05	-.1062E-05	.5103E-08	0.001	HEAT INTO POINT= -.712520E-03	HEAT CONDUCTED AWAY FROM POINT= -.712525E-03
204	-.4889E-03	-.4879E-03	-.1437E-05	-.1001E-05	-.9696E-06	-.4256E-06	.7035E-08	0.001	HEAT INTO POINT= -.490275E-03	HEAT CONDUCTED AWAY FROM POINT= -.490282E-03
205	-.2492E-03	-.2488E-03	-.1001E-05	-.8689E-06	-.3563E-06	-.1454E-06	.1684E-07	0.007	HEAT INTO POINT= -.250162E-03	HEAT CONDUCTED AWAY FROM POINT= -.250179E-03
206	-.4367E-03	-.4362E-03	-.8689E-06	-.6582E-06	-.5616E-06	-.2160E-06	.1723E-08	0.000	HEAT INTO POINT= -.437595E-03	HEAT CONDUCTED AWAY FROM POINT= -.437596E-03

TABLE H21 (continued)

207	-.3738E-03	-.3735E-03	-.6582E-06	0.	0.	-.3267E-06	.9269E-09	0.000
	HEAT INTO POINT= -.374111E-03		HEAT CONDUCTED AWAY FROM POINT= -.374112E-03					
212	-.6425E-03	-.6320E-03	0.	.2442E-06	-.1395E-04	-.3666E-05	.6304E-09	0.000
	HEAT INTO POINT= -.645961E-03		HEAT CONDUCTED AWAY FROM POINT= -.645962E-03					
213	-.1261E-02	-.1240E-02	.2442E-06	-.2783E-05	-.3126E-04	-.7930E-05	.1166E-08	0.000
	HEAT INTO POINT= -.127127E-02		HEAT CONDUCTED AWAY FROM POINT= -.127127E-02					
214	-.1185E-02	-.1171E-02	-.2783E-05	-.3670E-05	-.1960E-04	-.5108E-05	.1717E-08	0.000
	HEAT INTO POINT= -.119367E-02		HEAT CONDUCTED AWAY FROM POINT= -.119368E-02					
215	-.1064E-02	-.1057E-02	-.3670E-05	-.2381E-05	-.7535E-05	-.2105E-05	.2490E-08	0.000
	HEAT INTO POINT= -.106866E-02		HEAT CONDUCTED AWAY FROM POINT= -.106866E-02					
216	-.9041E-03	-.9011E-03	-.2381E-05	-.1376E-05	-.2601E-05	-.7969E-06	.3439E-08	0.000
	HEAT INTO POINT= -.906261E-03		HEAT CONDUCTED AWAY FROM POINT= -.906265E-03					
217	-.7097E-03	-.7084E-03	-.1376E-05	-.8325E-06	-.1082E-05	-.3066E-06	.4534E-08	0.001
	HEAT INTO POINT= -.710818E-03		HEAT CONDUCTED AWAY FROM POINT= -.710823E-03					
218	-.4887E-03	-.4882E-03	-.8325E-06	-.5704E-06	-.4256E-06	-.1185E-06	.6195E-08	0.001
	HEAT INTO POINT= -.489410E-03		HEAT CONDUCTED AWAY FROM POINT= -.489416E-03					
219	-.2491E-03	-.2489E-03	-.5704E-06	-.4730E-06	-.1454E-06	-.3778E-07	.1461E-07	0.006
	HEAT INTO POINT= -.249617E-03		HEAT CONDUCTED AWAY FROM POINT= -.249632E-03					
220	-.4367E-03	-.4363E-03	-.4730E-06	-.2861E-06	-.2160E-05	-.5312E-07	-.6944E-09	-0.000
	HEAT INTO POINT= -.436997E-03		HEAT CONDUCTED AWAY FROM POINT= -.436997E-03					
221	-.7475E-03	-.7471E-03	-.2861E-06	-.1651E-06	-.3267E-06	-.7943E-07	.2953E-08	0.000
	HEAT INTO POINT= -.747695E-03		HEAT CONDUCTED AWAY FROM POINT= -.747698E-03					
222	-.3737E-03	-.3736E-03	-.1651E-06	0.	0.	-.4921E-07	.1324E-08	0.000
	HEAT INTO POINT= -.373759E-03		HEAT CONDUCTED AWAY FROM POINT= -.373760E-03					
226	-.3207E-03	-.3170E-03	0.	-.1686E-09	-.3686E-05	0.	.9196E-10	0.000
	HEAT INTO POINT= -.320708E-03		HEAT CONDUCTED AWAY FROM POINT= -.320708E-03					
227	-.6291E-03	-.6221E-03	-.1686E-09	-.9363E-06	-.7930E-05	0.	.6935E-10	0.000
	HEAT INTO POINT= -.630034E-03		HEAT CONDUCTED AWAY FROM POINT= -.630034E-03					
228	-.5918E-03	-.5870E-03	-.9363E-06	-.1255E-05	-.5106E-05	0.	.1437E-09	0.000
	HEAT INTO POINT= -.593039E-03		HEAT CONDUCTED AWAY FROM POINT= -.593039E-03					
229	-.5318E-03	-.5293E-03	-.1255E-05	-.8815E-06	-.2105E-05	0.	.2793E-09	0.000

TABLE H21 (continued)

	HEAT INTO POINT= -.532663E-03			HEAT CONDUCTED AWAY FROM POINT= -.532663E-03				
230	-.4519E-03	-.4508E-03	-.8815E-06	-.5337E-06	-.7989E-06	0.	.5330E-09	0.000
	HEAT INTO POINT= -.452467E-03			HEAT CONDUCTED AWAY FROM POINT= -.452466E-03				
231	-.3549E-03	-.3544E-03	-.5337E-06	-.3274E-06	-.3086E-06	0.	.9992E-09	0.000
	HEAT INTO POINT= -.355212E-03			HEAT CONDUCTED AWAY FROM POINT= -.355213E-03				
232	-.2443E-03	-.2441E-03	-.3274E-06	-.2171E-06	-.1185E-06	0.	.1968E-08	0.001
	HEAT INTO POINT= -.244561E-03			HEAT CONDUCTED AWAY FROM POINT= -.244563E-03				
233	-.1246E-03	-.1245E-03	-.2171E-06	-.1699E-06	-.3778E-07	0.	.6299E-08	0.005
	HEAT INTO POINT= -.124716E-03			HEAT CONDUCTED AWAY FROM POINT= -.124725E-03				
234	-.1246E-03	-.1245E-03	-.1699E-06	-.1373E-06	-.5312E-07	0.	-.1243E-08	-0.001
	HEAT INTO POINT= -.124690E-03			HEAT CONDUCTED AWAY FROM POINT= -.124689E-03				
235	-.3737E-03	-.3736E-03	-.1373E-06	-.6742E-07	-.7943E-07	0.	.2255E-09	0.000
	HEAT INTO POINT= -.373791E-03			HEAT CONDUCTED AWAY FROM POINT= -.373791E-03				
236	-.3737E-03	-.3736E-03	-.6742E-07	-.2028E-07	-.4921E-07	0.	.2541E-09	0.000
	HEAT INTO POINT= -.373724E-03			HEAT CONDUCTED AWAY FROM POINT= -.373724E-03				
237	-.9342E-04	-.9340E-04	-.2028E-07	0.	0.	0.	-.1581E-09	-0.000
	HEAT INTO POINT= -.934246E-04			HEAT CONDUCTED AWAY FROM POINT= -.934244E-04				
272	-.8337E-03	-.8695E-03	.2833E-04	.1626E-04	.4765E-04	.2390E-04	.4233E-08	0.001
	HEAT INTO POINT= -.793498E-03			HEAT CONDUCTED AWAY FROM POINT= -.793502E-03				
273	-.3322E-03	-.3390E-03	.1626E-04	0.	0.	.9433E-05	.2891E-08	0.001
	HEAT INTO POINT= -.322765E-03			HEAT CONDUCTED AWAY FROM POINT= -.322768E-03				
285	-.6724E-03	-.7042E-03	.1561E-04	.9425E-05	.6773E-04	.4206E-04	.5044E-08	0.001
	HEAT INTO POINT= -.620871E-03			HEAT CONDUCTED AWAY FROM POINT= -.620876E-03				
286	-.5818E-03	-.5945E-03	.9425E-05	.5157E-05	.2390E-04	.1548E-04	.6498E-08	0.001
	HEAT INTO POINT= -.561163E-03			HEAT CONDUCTED AWAY FROM POINT= -.561169E-03				
287	-.4603E-03	-.4655E-03	.5157E-05	.3304E-05	.9433E-05	.6096E-05	.7366E-08	0.002
	HEAT INTO POINT= -.450862E-03			HEAT CONDUCTED AWAY FROM POINT= -.450869E-03				
288	-.1590E-03	-.1600E-03	.3304E-05	0.	0.	.2272E-05	.4077E-08	0.003
	HEAT INTO POINT= -.156703E-03			HEAT CONDUCTED AWAY FROM POINT= -.156707E-03				
298	-.3757E-03	-.3999E-03	.5255E-05	.4631E-05	.9457E-04	.7095E-04	.9977E-08	0.003
	HEAT INTO POINT= -.300071E-03			HEAT CONDUCTED AWAY FROM POINT= -.300081E-03				

TABLE H21 (continued)

299	-.4969E-03	-.5116E-03	.4631E-05	.2703E-05	.4206E-04	.2935E-04	.1294E-07	0.003
	HEAT INTO POINT= -.464873E-03		HEAT CONDUCTED AWAY FROM POINT= -.464866E-03					
300	-.2980E-03	-.3023E-03	.2703E-05	.1656E-05	.1548E-04	.1220E-04	.1550E-07	0.005
	HEAT INTO POINT= -.284132E-03		HEAT CONDUCTED AWAY FROM POINT= -.284146E-03					
301	-.2352E-03	-.2370E-03	.1656E-05	.1060E-05	.6096E-05	.4665E-05	.1617E-07	0.007
	HEAT INTO POINT= -.229244E-03		HEAT CONDUCTED AWAY FROM POINT= -.229260E-03					
302	-.1623E-03	-.1630E-03	.1080E-05	.7649E-06	.2272E-05	.1845E-05	.1429E-07	0.009
	HEAT INTO POINT= -.159678E-03		HEAT CONDUCTED AWAY FROM POINT= -.159692E-03					
303	-.4142E-04	-.4155E-04	.7649E-06	0.	0.	.6282E-06	.6505E-06	0.016
	HEAT INTO POINT= -.407640E-04		HEAT CONDUCTED AWAY FROM POINT= -.407905E-04					
311	-.6895E-03	-.7481E-03	.2398E-05	.7423E-05	.1253E-03	.6172E-04	-.6100E-09	-0.000
	HEAT INTO POINT= -.620395E-03		HEAT CONDUCTED AWAY FROM POINT= -.620394E-03					
312	-.6633E-03	-.6988E-03	.7423E-05	.6539E-05	.7095E-04	.3632E-04	-.1136E-08	-0.000
	HEAT INTO POINT= -.620471E-03		HEAT CONDUCTED AWAY FROM POINT= -.620470E-03					
313	-.6093E-03	-.6247E-03	.6539E-05	.3955E-05	.2935E-04	.1655E-04	-.1242E-08	-0.000
	HEAT INTO POINT= -.588839E-03		HEAT CONDUCTED AWAY FROM POINT= -.588837E-03					
314	-.5230E-03	-.5295E-03	.3955E-05	.2454E-05	.1220E-04	.7166E-05	-.1084E-08	-0.000
	HEAT INTO POINT= -.513365E-03		HEAT CONDUCTED AWAY FROM POINT= -.513363E-03					
315	-.4125E-03	-.4152E-03	.2454E-05	.1613E-05	.4665E-05	.2968E-05	-.2785E-09	-0.000
	HEAT INTO POINT= -.407924E-03		HEAT CONDUCTED AWAY FROM POINT= -.407924E-03					
316	-.2646E-03	-.2857E-03	.1613E-05	.1156E-05	.1845E-05	.1161E-05	.1730E-08	0.001
	HEAT INTO POINT= -.282253E-03		HEAT CONDUCTED AWAY FROM POINT= -.282255E-03					
317	-.1452E-03	-.1456E-03	.1156E-05	.9546E-06	.6282E-06	.4171E-06	.9757E-08	0.007
	HEAT INTO POINT= -.143819E-03		HEAT CONDUCTED AWAY FROM POINT= -.143829E-03					
318	-.1273E-03	-.1276E-03	.9546E-06	0.	0.	.6447E-06	-.1685E-08	-0.001
	HEAT INTO POINT= -.126629E-03		HEAT CONDUCTED AWAY FROM POINT= -.126628E-03					
324	-.6241E-03	-.6443E-03	0.	.1907E-05	.3467E-04	.1251E-04	.5368E-09	0.000
	HEAT INTO POINT= -.609669E-03		HEAT CONDUCTED AWAY FROM POINT= -.609670E-03					
325	-.1224E-02	-.1262E-02	.1907E-05	.4296E-05	.6172E-04	.2149E-04	.8979E-09	0.000
	HEAT INTO POINT= -.119865E-02		HEAT CONDUCTED AWAY FROM POINT= -.119865E-02					
326	-.1162E-02	-.1166E-02	.4296E-05	.3692E-05	.3632E-04	.1307E-04	.1311E-08	0.000

TABLE H21 (continued)

HEAT INTO POINT= -.114494E-02 HEAT CONDUCTED AWAY FROM POINT= -.114494E-02

327	-.1053E-02	-.1065E-02	.3692E-05	.2457E-05	.1655E-04	.6477E-05	.1966E-08	0.000	HEAT INTO POINT= -.104432E-02	HEAT CONDUCTED AWAY FROM POINT= -.104432E-02
328	-.8994E-03	-.9044E-03	.2457E-05	.1627E-05	.7166E-05	.2960E-05	.2838E-08	0.000	HEAT INTO POINT= -.894762E-03	HEAT CONDUCTED AWAY FROM POINT= -.894765E-03
329	-.7077E-03	-.7098E-03	.1627E-05	.1129E-05	.2968E-05	.1279E-05	.3999E-08	0.001	HEAT INTO POINT= -.705240E-03	HEAT CONDUCTED AWAY FROM POINT= -.705244E-03
330	-.4879E-03	-.4868E-03	.1129E-05	.8647E-06	.1161E-05	.5205E-06	.5972E-08	0.001	HEAT INTO POINT= -.486477E-03	HEAT CONDUCTED AWAY FROM POINT= -.486463E-03
331	-.2488E-03	-.2491E-03	.8647E-06	.7558E-06	.4171E-06	.1783E-06	.1552E-07	0.006	HEAT INTO POINT= -.247855E-03	HEAT CONDUCTED AWAY FROM POINT= -.247870E-03
332	-.4362E-03	-.4367E-03	.7558E-06	.6221E-06	.6447E-06	.2652E-06	.1037E-06	0.000	HEAT INTO POINT= -.435276E-03	HEAT CONDUCTED AWAY FROM POINT= -.435277E-03
333	-.3735E-03	-.3737E-03	.6221E-06	0.	0.	.3259E-06	.4360E-09	0.000	HEAT INTO POINT= -.373126E-03	HEAT CONDUCTED AWAY FROM POINT= -.373127E-03
338	-.6320E-03	-.6406E-03	0.	.8429E-06	.1251E-04	.3065E-05	.4752E-09	0.000	HEAT INTO POINT= -.628085E-03	HEAT CONDUCTED AWAY FROM POINT= -.628086E-03
339	-.1240E-02	-.1256E-02	.8429E-06	.1531E-05	.2149E-04	.5210E-05	.8087E-09	0.000	HEAT INTO POINT= -.123351E-02	HEAT CONDUCTED AWAY FROM POINT= -.123351E-02
340	-.1171E-02	-.1182E-02	.1531E-05	.1234E-05	.1307E-04	.3226E-05	.1206E-08	0.000	HEAT INTO POINT= -.116703E-02	HEAT CONDUCTED AWAY FROM POINT= -.116703E-02
341	-.1057E-02	-.1063E-02	.1234E-05	.8670E-06	.6477E-05	.1673E-05	.1797E-08	0.000	HEAT INTO POINT= -.105491E-02	HEAT CONDUCTED AWAY FROM POINT= -.105492E-02
342	-.9011E-03	-.9035E-03	.8670E-06	.6145E-06	.2960E-05	.7917E-06	.2577E-08	0.000	HEAT INTO POINT= -.899670E-03	HEAT CONDUCTED AWAY FROM POINT= -.899673E-03
343	-.7084E-03	-.7095E-03	.6145E-06	.4472E-06	.1279E-05	.3506E-06	.3585E-08	0.001	HEAT INTO POINT= -.707556E-03	HEAT CONDUCTED AWAY FROM POINT= -.707562E-03
344	-.4852E-03	-.4886E-03	.4472E-06	.3402E-06	.5205E-06	.1436E-06	.5274E-08	0.001	HEAT INTO POINT= -.487663E-03	HEAT CONDUCTED AWAY FROM POINT= -.487668E-03
345	-.2499E-03	-.2491E-03	.3402E-06	.2752E-06	.1783E-06	.4814E-07	.1347E-07	0.005	HEAT INTO POINT= -.248565E-03	HEAT CONDUCTED AWAY FROM POINT= -.248578E-03

TABLE H21 (continued)

346	-.4363E-03	-.4366E-03	.2752E-06	.1828E-06	.2652E-06	.7035E-07	-.1167E-08	-0.000
	HEAT INTO POINT= -.436056E-03		HEAT CONDUCTED AWAY FROM POINT= -.436055E-03					
347	-.7471E-03	-.7474E-03	.1826E-06	.1264E-06	.3259E-06	.8199E-07	.2062E-08	0.000
	HEAT INTO POINT= -.746872E-03		HEAT CONDUCTED AWAY FROM POINT= -.746874E-03					
348	-.3736E-03	-.3737E-03	.1264E-06	0.	0.	.3893E-07	.9426E-09	0.000
	HEAT INTO POINT= -.373554E-03		HEAT CONDUCTED AWAY FROM POINT= -.373555E-03					
352	-.3170E-03	-.3198E-03	0.	.2743E-06	.3085E-05	0.	.2906E-10	0.000
	HEAT INTO POINT= -.316748E-03		HEAT CONDUCTED AWAY FROM POINT= -.316748E-03					
353	-.6221E-03	-.6271E-03	.2743E-06	.4411E-06	.5210E-05	0.	-.6966E-10	-0.000
	HEAT INTO POINT= -.621663E-03		HEAT CONDUCTED AWAY FROM POINT= -.621663E-03					
354	-.5870E-03	-.5903E-03	.4411E-06	.3308E-06	.3226E-05	0.	-.5265E-10	-0.000
	HEAT INTO POINT= -.586664E-03		HEAT CONDUCTED AWAY FROM POINT= -.586664E-03					
355	-.5293E-03	-.5311E-03	.3308E-06	.2366E-06	.1673E-05	0.	.1195E-10	0.000
	HEAT INTO POINT= -.529066E-03		HEAT CONDUCTED AWAY FROM POINT= -.529066E-03					
356	-.4508E-03	-.4516E-03	.2366E-06	.1760E-06	.7917E-06	0.	.1966E-09	0.000
	HEAT INTO POINT= -.450611E-03		HEAT CONDUCTED AWAY FROM POINT= -.450611E-03					
357	-.3544E-03	-.3548E-03	.1760E-06	.1311E-06	.3506E-06	0.	.6257E-09	0.000
	HEAT INTO POINT= -.354238E-03		HEAT CONDUCTED AWAY FROM POINT= -.354238E-03					
358	-.2441E-03	-.2443E-03	.1311E-06	.9462E-07	.1436E-06	0.	.1593E-08	0.001
	HEAT INTO POINT= -.244019E-03		HEAT CONDUCTED AWAY FROM POINT= -.244021E-03					
359	-.1245E-03	-.1245E-03	.9462E-07	.6621E-07	.4814E-07	0.	.5797E-08	0.005
	HEAT INTO POINT= -.124392E-03		HEAT CONDUCTED AWAY FROM POINT= -.124397E-03					
360	-.1245E-03	-.1245E-03	.6621E-07	.7219E-07	.7035E-07	0.	-.1308E-08	-0.001
	HEAT INTO POINT= -.124397E-03		HEAT CONDUCTED AWAY FROM POINT= -.124395E-03					
361	-.3736E-03	-.3737E-03	.7219E-07	.4165E-07	.8199E-07	0.	-.1153E-09	-0.000
	HEAT INTO POINT= -.373533E-03		HEAT CONDUCTED AWAY FROM POINT= -.373533E-03					
362	-.3736E-03	-.3737E-03	.4165E-07	.1316E-07	.3893E-07	0.	-.3845E-10	-0.000
	HEAT INTO POINT= -.373594E-03		HEAT CONDUCTED AWAY FROM POINT= -.373594E-03					
363	-.9340E-04	-.9342E-04	.1316E-07	0.	0.	0.	-.2131E-09	-0.000
	HEAT INTO POINT= -.934045E-04		HEAT CONDUCTED AWAY FROM POINT= -.934043E-04					

QXY(131)= -.3151E-05 GRAD(1,3)= -.7260E-04 QYX(258)= -.3868E-03 HEATIN= -.4648E-03

QZX(132)= -.4029E-04 QYX(132)= -.4245E-03 HEATOUT= -.4648E-03 TOTFLO= .2911E-08 HEAT BALANCE ERROR %= 0.001

TABLE H21 (continued)

```
     QXY(257)=  .9439E-05        QRAD(1,4)=  .7575E-04        QYX(384)= -.4263E-03        HEATIN= -.3412E-03
     QZX(258)=  .4765E-04       QYX(258)= -.3888E-03       HEATOUT= -.3412E-03      TOTFLO=  .2342E-08      HEAT BALANCE ERROR %= 0.001
     QZX(131)= -.6249E-05        QRAD(2,3)= -.1456E-03        QYX(271)= -.7895E-03        HEATIN= -.9413E-03
PT NO145QYX= -.8619E-03     QXY= -.2716E-04     QZX= -.5231E-04     HEATOUT= -.9413E-03      TOTFLO=  .5666E-08       %ERROR= 0.001
     QZX(257)=  .1903E-04        QRAD(2,4)=  .1515E-03        QYX(397)= -.6640E-03        HEATIN= -.6934E-03
PT NO271QYX= -.7895E-03     QXY=  .2833E-04     QZX=  .6773E-04     HEATOUT= -.6934E-03      TOTFLO=  .4605E-08       %ERROR= 0.001
     QXY(157)= -.8831E-04        QRAD(3,3)= -.1456E-03        QYX(284)= -.6665E-03        HEATIN= -.9024E-03
PT NO158QYX= -.7507E-03     QXY= -.2836E-04     QZX= -.1234E-03     HEATOUT= -.9024E-03      TOTFLO=  .5490E-08       %ERROR= 0.001
     QXY(283)=  .3159E-04        QRAD(3,4)=  .1515E-03        QYX(410)= -.7414E-03        HEATIN= -.5583E-03
PT NO284QYX= -.6685E-03     QXY=  .1561E-04     QZX=  .9457E-04   - HEATOUT= -.5583E-03      TOTFLO=  .4666E-08       %ERROR= 0.001
     QZX(157)= -.8843E-04        QRAD(4,3)= -.1456E-03        QYX(297)= -.5058E-03        HEATIN= -.7399E-03
PT NO171QYX= -.5657E-03     QXY= -.7326E-05     QZX= -.1668E-03     HEATOUT= -.7399E-03      TOTFLO=  .7828E-08       %ERROR= 0.001
     QZX(283)=  .3177E-04        QRAD(4,4)=  .1515E-03        QYX(423)= -.5585E-03        HEATIN= -.3752E-03
PT NO297QYX= -.5058E-03     QXY=  .5255E-05     QZX=  .1253E-03     HEATOUT= -.3752E-03      TOTFLO=  .7101E-08       %ERROR= 0.002
     QXY(183)=  .9840E-06        QRAD(5,3)= -.7280E-04        QYX(310)= -.4597E-03        HEATIN= -.5315E-03
PT NO184QYX= -.5009E-03     QXY=  .4278E-05     QZX= -.3496E-04     HEATOUT= -.5315E-03      TOTFLO=  .7483E-09       %ERROR= 0.000
     QXY(309)=  .5899E-06        QRAD(5,4)=  .7575E-04        QYX(436)= -.4990E-03        HEATIN= -.4227E-03
PT NO310QYX= -.4597E-03     QXY=  .2398E-05     QZX=  .3467E-04     HEATOUT= -.4227E-03      TOTFLO=  .5993E-09       %ERROR= 0.000
     QXY(128)=  .1069E-05        QYX(255)= -.2495E-03        HEATIN= -.2485E-03
PT NO129QYX= -.2967E-03     QXY=  .2366E-06     QZX=  .4802E-04     HEATOUT= -.2485E-03      TOTFLO=  .3553E-14       %ERROR= 0.000
     QXY(254)=  .3825E-06        QYX(381)= -.2780E-03        HEATIN= -.2777E-03
PT NO255QYX= -.2495E-03     QXY= -.9008E-05     QZX= -.1912E-04     HEATOUT= -.2777E-03      TOTFLO=  .1776E-13       %ERROR= 0.000
        REGION  NUMBER           SUM OF QYX           SUM OF QXY           SUM OF QZX           SUM OF QY,QX AND QZ
            C2                   -.297138E-01         -.184403E-03         -.898105E-03          .307963E-01
            C3                   -.290786E-01          .146351E-03          .789799E-03          .300147E-01
            C4                   -.296520E-01         0.                   0.                    .296520E-01
              TOTAL HEAT CONDUCTED IN SOLID=TOSOCO=  .904630E-01
        REGION  NUMBER           QYXAIR(J)            QXYAIR(J)            QZXAIR(J)            SUM OF REGIONAL AIR CONDUCTION
            C2                   -.401885E-02         -.902457E-04         -.466554E-04          .415575E-02
            C3                   -.198802E-02          .326132E-04          .316736E-04          .205230E-02
            C4                   -.364376E-02         0.                   0.                    .364376E-02
              TOTAL HEAT CONDUCTED BY AIR=  .985182E-02IN WATTS

SOLIDCO=  .307963E-01          AIRCO=  .415575E-02          TOTRAD=  .130561E-02          HEAT TRANSFERED=  .362576E-01
              HEAT TRANSFERED BY THE THREE MODES FOR THE WHOLE PLATE IN THE EXPERIMENT IS
SOLID CONDUCTION=  .394192E+01     AIR CONDUCTION=  .531936E+00     RADIATION=  .167119E+00     TOTAL HEAT TRANSFERED=  .464098E+01
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TABLE H22

Values of dQr/dT For Run 568A

J	DQDT(I,J) W/^{o}C				
	I				
	1	2	3	4	5
2	-0.000021	-0.000043	-0.000043	-0.000043	-0.000021
3	-0.000034	-0.000068	-0.000068	-0.000068	-0.000034
4	-0.000033	-0.000066	-0.000066	-0.000066	-0.000033
5	-0.000020	-0.000039	-0.000039	-0.000039	-0.000020

TABLE H23

Net Radiation Flows For Run 568A

I	QRADTO(I) in Watts
1	-0.001698
2	-0.006417
3	-0.004659
4	0.004848
5	0.006283
6	0.001643

where QRADTO(I) is the net radiative loss from surface I resulting from radiation in the enclosure

TABLE H24

Radiation Flows Towards Surface Points

J	QRAD(I,J) in Watts				
	I				
	1	2	3	4	5
2	-0.0001033	-0.0002005	-0.0002005	-0.0002005	-0.0001003
3	-0.0000728	-0.0001456	-0.0001456	-0.0001456	-0.0000728
4	0.0000758	0.0001515	0.0001515	0.0001515	0.0000758
5	0.0000982	0.0001964	0.0001964	0.0001064	0.0000982

where QRAD(I,J) is the radiation flow to the surface point as defined in Appendix B

H3 CONDUCTANCES

Table H25 shows the conductances between nodal points (results of run 568A).

TABLE H25 - Conductances For Simulation Run 568A

NX= 14 NY= 4 NZ= 9

THE THERMAL CONDUCTIVITY OF PERSPEX=0.2000IN WATTS PER METRE PER DEGREE C
THE THICKNESS OF PERSPEX DIVIDED BY 3 IN METRES= .370E-02

	CONDUCTANCE	HC	AC	DC		
CXY(145)=	0.000530	0.715200	1.000000	1.000000	CXY(271)=	0.000530
CXY(146)=	0.000645	0.871400	1.000000	1.000000	CXY(272)=	0.000645
CXY(158)=	0.000320	0.431900	1.000000	1.000000	CXY(284)=	0.000320
CXY(159)=	0.000365	1.000000	1.325000	2.690000	CXY(285)=	0.000365
CXY(160)=	0.000444	1.000000	1.325000	2.208000	CXY(286)=	0.000444
CXY(161)=	0.000598	0.807900	1.000000	1.000000	CXY(287)=	0.000598
CXY(171)=	0.000150	0.202900	1.000000	1.000000	CXY(297)=	0.000150
CXY(172)=	0.000163	1.000000	0.675500	3.068000	CXY(298)=	0.000163
CXY(173)=	0.000186	1.000000	0.675500	2.690000	CXY(299)=	0.000186
CXY(174)=	0.000227	1.000000	0.675500	2.208000	CXY(300)=	0.000227
CXY(175)=	0.000305	1.000000	0.675500	1.640000	CXY(301)=	0.000305
CXY(176)=	0.000495	0.668800	1.000000	1.000000	CXY(302)=	0.000495
CXY(184)=	0.000253	0.341900	1.000000	1.000000	CXY(310)=	0.000253
CXY(185)=	0.000263	1.000000	1.184000	3.330000	CXY(311)=	0.000263
CXY(186)=	0.000286	1.000000	1.184000	3.068000	CXY(312)=	0.000286
CXY(187)=	0.000326	1.000000	1.184000	2.690000	CXY(313)=	0.000326
CXY(188)=	0.000397	1.000000	1.184000	2.208000	CXY(314)=	0.000397
CXY(189)=	0.000535	1.000000	1.184000	1.640000	CXY(315)=	0.000535
CXY(190)=	0.000868	1.000000	1.184000	1.010000	CXY(316)=	0.000868
CXY(191)=	0.002571	3.472100	1.000000	1.000000	CXY(317)=	0.002571
CXY(198)=	0.000433	1.000000	2.027000	3.463000	CXY(324)=	0.000433
CXY(199)=	0.000451	1.000000	2.027000	3.330000	CXY(325)=	0.000451
CXY(200)=	0.000489	1.000000	2.027000	3.068000	CXY(326)=	0.000489
CXY(201)=	0.000558	1.000000	2.027000	2.690000	CXY(327)=	0.000558
CXY(202)=	0.000660	1.000000	2.027000	2.208000	CXY(328)=	0.000660
CXY(203)=	0.000915	1.000000	2.027000	1.640000	CXY(329)=	0.000915
CXY(204)=	0.001486	1.000000	2.027000	1.010000	CXY(330)=	0.001486
CXY(205)=	0.004401	1.000000	2.027000	0.341000	CXY(331)=	0.004401
CXY(206)=	0.001481	1.000000	2.000000	1.000000	CXY(332)=	0.001481
CXY(212)=	0.000433	1.000000	2.027000	3.463000	CXY(338)=	0.000433
CXY(213)=	0.000451	1.000000	2.027000	3.330000	CXY(339)=	0.000451
CXY(214)=	0.000489	1.000000	2.027000	3.068000	CXY(340)=	0.000489
CXY(215)=	0.000558	1.000000	2.027000	2.690000	CXY(341)=	0.000558

CXY(216)=	0.000660	1.000000	2.027000	2.208000	CXY(342)=	0.000660
CXY(217)=	0.000915	1.000000	2.027000	1.640000	CXY(343)=	0.000915
CXY(218)=	0.001486	1.000000	2.027000	1.010000	CXY(344)=	0.001486
CXY(219)=	0.004401	1.000000	2.027000	0.341000	CXY(345)=	0.004401
CXY(220)=	0.000740	1.000000	2.027000	2.027000	CXY(346)=	0.000740
CXY(221)=	0.000740	1.000000	1.000000	1.000000	CXY(347)=	0.000740
CXY(226)=	0.000217	1.000000	1.013500	3.463000	CXY(352)=	0.000217
CXY(227)=	0.000225	1.000000	1.013500	3.330000	CXY(353)=	0.000225
CXY(228)=	0.000245	1.000000	1.013500	3.068000	CXY(354)=	0.000245
CXY(229)=	0.000279	1.000000	1.013500	2.690000	CXY(355)=	0.000279
CXY(230)=	0.000340	1.000000	1.013500	2.208000	CXY(356)=	0.000340
CXY(231)=	0.000458	1.000000	1.013500	1.640000	CXY(357)=	0.000458
CXY(232)=	0.000743	1.000000	1.013500	1.010000	CXY(358)=	0.000743
CXY(233)=	0.002201	1.000000	1.013500	0.341000	CXY(359)=	0.002201
CXY(234)=	0.000370	1.000000	1.013500	2.027000	CXY(360)=	0.000370
CXY(235)=	0.000370	1.000000	1.013500	2.027000	CXY(361)=	0.000370
CXY(236)=	0.000370	0.500000	1.000000	1.000000	CXY(362)=	0.000370

THE CONDUCTANCES OF CYX AND CYZ ARE

CYX(132)=	0.000073	CYX(258)=	0.000073	CYX(384)=	0.000073	AC=	1.351800
CYX(145)=	0.000150	CYX(271)=	0.000150	CYX(397)=	0.000150	AC=	2.709600
CYX(146)=	0.000255	CYX(272)=	0.000255	CYX(398)=	0.000255	AC=	4.711900
CYX(147)=	0.000100	CYX(273)=	0.000100	CYX(399)=	0.000100	AC=	1.050900
CYX(158)=	0.000114	CYX(284)=	0.000114	CYX(410)=	0.000114	AC=	2.119300
CYX(159)=	0.000206	CYX(285)=	0.000206	CYX(411)=	0.000206	AC=	3.014700
CYX(160)=	0.000175	CYX(286)=	0.000175	CYX(412)=	0.000175	AC=	3.244900
CYX(161)=	0.000138	CYX(287)=	0.000138	CYX(413)=	0.000138	AC=	2.549300
CYX(162)=	0.000047	CYX(288)=	0.000047	CYX(414)=	0.000047	AC=	0.077600
CYX(171)=	0.000062	CYX(297)=	0.000062	CYX(423)=	0.000062	AC=	1.147200
CYX(172)=	0.000117	CYX(298)=	0.000117	CYX(424)=	0.000117	AC=	2.160900
CYX(173)=	0.000151	CYX(299)=	0.000151	CYX(425)=	0.000151	AC=	2.787400
CYX(174)=	0.000089	CYX(300)=	0.000089	CYX(426)=	0.000089	AC=	1.054300
CYX(175)=	0.000070	CYX(301)=	0.000070	CYX(427)=	0.000070	AC=	1.299700
CYX(176)=	0.000048	CYX(302)=	0.000048	CYX(428)=	0.000048	AC=	0.095000
CYX(177)=	0.000012	CYX(303)=	0.000012	CYX(429)=	0.000012	AC=	0.228200
CYX(184)=	0.000095	CYX(310)=	0.000095	CYX(436)=	0.000095	AC=	1.754900
CYX(185)=	0.000217	CYX(311)=	0.000217	CYX(437)=	0.000217	AC=	4.021500
CYX(186)=	0.000205	CYX(312)=	0.000205	CYX(438)=	0.000205	AC=	3.757600
CYX(187)=	0.000184	CYX(313)=	0.000184	CYX(439)=	0.000184	AC=	3.406700
CYX(188)=	0.000157	CYX(314)=	0.000157	CYX(440)=	0.000157	AC=	2.099600

TABLE H25 (continued)

CYX(189)=	0.000123	CYX(315)=	0.000123	CYX(441)=	0.000123	AC=	2.276000
CYX(190)=	0.000085	CYX(316)=	0.000085	CYX(442)=	0.000085	AC=	1.568800
CYX(191)=	0.000043	CYX(317)=	0.000043	CYX(443)=	0.000043	AC=	0.799800
CYX(192)=	0.000038	CYX(318)=	0.000038	CYX(444)=	0.000038	AC=	0.700900
CYX(198)=	0.000190	CYX(324)=	0.000190	CYX(450)=	0.000190	AC=	3.509800
CYX(199)=	0.000372	CYX(325)=	0.000372	CYX(451)=	0.000372	AC=	6.684700
CYX(200)=	0.000350	CYX(326)=	0.000350	CYX(452)=	0.000350	AC=	6.484400
CYX(201)=	0.000315	CYX(327)=	0.000315	CYX(453)=	0.000315	AC=	5.635700
CYX(202)=	0.000268	CYX(328)=	0.000268	CYX(454)=	0.000268	AC=	4.964100
CYX(203)=	0.000211	CYX(329)=	0.000211	CYX(455)=	0.000211	AC=	3.699000
CYX(204)=	0.000145	CYX(330)=	0.000145	CYX(456)=	0.000145	AC=	2.685600
CYX(205)=	0.000074	CYX(331)=	0.000074	CYX(457)=	0.000074	AC=	1.369200
CYX(206)=	0.000130	CYX(332)=	0.000130	CYX(458)=	0.000130	AC=	2.400000
CYX(207)=	0.000111	CYX(333)=	0.000111	CYX(459)=	0.000111	AC=	2.654400
CYX(212)=	0.000190	CYX(338)=	0.000190	CYX(464)=	0.000190	AC=	3.509800
CYX(213)=	0.000372	CYX(339)=	0.000372	CYX(465)=	0.000372	AC=	6.684700
CYX(214)=	0.000350	CYX(340)=	0.000350	CYX(466)=	0.000350	AC=	6.484400
CYX(215)=	0.000315	CYX(341)=	0.000315	CYX(467)=	0.000315	AC=	5.635700
CYX(216)=	0.000268	CYX(342)=	0.000268	CYX(468)=	0.000268	AC=	4.964100
CYX(217)=	0.000211	CYX(343)=	0.000211	CYX(469)=	0.000211	AC=	3.699000
CYX(218)=	0.000145	CYX(344)=	0.000145	CYX(470)=	0.000145	AC=	2.685600
CYX(219)=	0.000074	CYX(345)=	0.000074	CYX(471)=	0.000074	AC=	1.369200
CYX(220)=	0.000130	CYX(346)=	0.000130	CYX(472)=	0.000130	AC=	2.400000
CYX(221)=	0.000222	CYX(347)=	0.000222	CYX(473)=	0.000222	AC=	4.103700
CYX(222)=	0.000111	CYX(348)=	0.000111	CYX(474)=	0.000111	AC=	2.654400
CYX(226)=	0.000095	CYX(352)=	0.000095	CYX(478)=	0.000095	AC=	1.754900
CYX(227)=	0.000186	CYX(353)=	0.000186	CYX(479)=	0.000186	AC=	3.442400
CYX(228)=	0.000175	CYX(354)=	0.000175	CYX(480)=	0.000175	AC=	3.242200
CYX(229)=	0.000158	CYX(355)=	0.000158	CYX(481)=	0.000158	AC=	2.917900
CYX(230)=	0.000134	CYX(356)=	0.000134	CYX(482)=	0.000134	AC=	2.482100
CYX(231)=	0.000105	CYX(357)=	0.000105	CYX(483)=	0.000105	AC=	1.950000
CYX(232)=	0.000073	CYX(358)=	0.000073	CYX(484)=	0.000073	AC=	1.342900
CYX(233)=	0.000037	CYX(359)=	0.000037	CYX(485)=	0.000037	AC=	0.684600
CYX(234)=	0.000037	CYX(360)=	0.000037	CYX(486)=	0.000037	AC=	0.684600
CYX(235)=	0.000111	CYX(361)=	0.000111	CYX(487)=	0.000111	AC=	2.654400
CYX(236)=	0.000111	CYX(362)=	0.000111	CYX(488)=	0.000111	AC=	2.654400
CYX(237)=	0.000028	CYX(363)=	0.000028	CYX(489)=	0.000028	AC=	0.513000

TABLE H25 (continued)

	CONDUCTANCE	HC	AC	DC		
CZX(132)=	0.000821	1.109100	1.000000	1.000000	CZX(258)=	0.000821
CZX(145)=	0.001300	1.755500	1.000000	1.000000	CZX(271)=	0.001300
CZX(146)=	0.000977	1.000000	2.165000	1.640000	CZX(272)=	0.000977
CZX(147)=	0.000869	1.173200	1.000000	1.000000	CZX(273)=	0.000869
CZX(158)=	0.002345	3.167300	1.000000	1.000000	CZX(284)=	0.002345
CZX(159)=	0.002111	1.000000	2.679000	1.010000	CZX(285)=	0.002111
CZX(160)=	0.001795	1.000000	2.449000	1.010000	CZX(286)=	0.001795
CZX(161)=	0.001410	1.000000	1.924000	1.010000	CZX(287)=	0.001410
CZX(162)=	0.000971	1.311900	1.000000	1.000000	CZX(288)=	0.000971
CZX(171)=	0.007374	9.958900	1.000000	1.000000	CZX(297)=	0.007374
CZX(172)=	0.006946	1.000000	3.199000	0.341000	CZX(298)=	0.006946
CZX(173)=	0.006251	1.000000	2.879000	0.341000	CZX(299)=	0.006251
CZX(174)=	0.005317	1.000000	2.449000	0.341000	CZX(300)=	0.005317
CZX(175)=	0.004178	1.000000	1.924000	0.341000	CZX(301)=	0.004178
CZX(176)=	0.002877	1.000000	1.325000	0.341000	CZX(302)=	0.002877
CZX(177)=	0.001467	1.980900	1.000000	1.000000	CZX(303)=	0.001467
CZX(184)=	0.000632	1.000000	1.731500	2.027000	CZX(310)=	0.000632
CZX(185)=	0.001241	1.000000	3.396500	2.027000	CZX(311)=	0.001241
CZX(186)=	0.001168	1.000000	3.199000	2.027000	CZX(312)=	0.001168
CZX(187)=	0.001052	1.000000	2.879000	2.027000	CZX(313)=	0.001052
CZX(188)=	0.000895	1.000000	2.449000	2.027000	CZX(314)=	0.000895
CZX(189)=	0.000703	1.000000	1.924000	2.027000	CZX(315)=	0.000703
CZX(190)=	0.000484	1.000000	1.325000	2.027000	CZX(316)=	0.000484
CZX(191)=	0.000247	1.000000	0.675500	2.027000	CZX(317)=	0.000247
CZX(192)=	0.000432	0.584100	1.000000	1.000000	CZX(318)=	0.000432
CZX(198)=	0.000632	1.000000	1.731500	2.027000	CZX(324)=	0.000632
CZX(199)=	0.001241	1.000000	3.396500	2.027000	CZX(325)=	0.001241
CZX(200)=	0.001168	1.000000	3.199000	2.027000	CZX(326)=	0.001168
CZX(201)=	0.001052	1.000000	2.879000	2.027000	CZX(327)=	0.001052
CZX(202)=	0.000895	1.000000	2.449000	2.027000	CZX(328)=	0.000895
CZX(203)=	0.000703	1.000000	1.924000	2.027000	CZX(329)=	0.000703
CZX(204)=	0.000484	1.000000	1.325000	2.027000	CZX(330)=	0.000484
CZX(205)=	0.000247	1.000000	0.675500	2.027000	CZX(331)=	0.000247
CZX(206)=	0.000432	1.000000	1.184000	2.027000	CZX(332)=	0.000432
CZX(207)=	0.000740	1.000000	1.000000	1.000000	CZX(333)=	0.000740
CZX(212)=	0.000632	1.000000	1.731500	2.027000	CZX(338)=	0.000632

TABLE H25 (continued)

CZX(213)=	0.001241	1.000000	3.396500	2.027000	CZX(339)=	0.001241
CZX(214)=	0.001168	1.000000	3.199000	2.027000	CZX(340)=	0.001168
CZX(215)=	0.001052	1.000000	2.679000	2.027000	CZX(341)=	0.001052
CZX(216)=	0.000895	1.000000	2.449000	2.027000	CZX(342)=	0.000895
CZX(217)=	0.000703	1.000000	1.924000	2.027000	CZX(343)=	0.000703
CZX(218)=	0.000464	1.000000	1.325000	2.027000	CZX(344)=	0.000464
CZX(219)=	0.000247	1.000000	0.675500	2.027000	CZX(345)=	0.000247
CZX(220)=	0.000432	1.000000	1.184000	2.027000	CZX(346)=	0.000432
CZX(221)=	0.000740	1.000000	2.027000	2.027000	CZX(347)=	0.000740
CZX(222)=	0.000740	1.000000	1.000000	1.000000	CZX(348)=	0.000740

R1= .10000E-02 R2= .51875E-02 R3= .93750E-02 R4= .13563E-01 IN METRES

THE CONDUCTANCES OF POINTS ASSOCIATED WITH AIR IN THE CAVITY ARE

CXY(127)= .999900E+31	CYX(127)=0.	CZX(127)= .999900E+31
CXY(128)= .464281E-05	CYX(128)=0.	CZX(128)=0.
CXY(129)= .139284E-04	CYX(129)= .810120E-04	CZX(129)= .185713E-04
CXY(130)= .999900E+31	CYX(130)=0.	CZX(130)=0.
CXY(131)= .162779E-04	CYX(131)= .176589E-03	CZX(131)= .325559E-04
CXY(132)=0.	CYX(132)= .122738E-03	CZX(132)= .821178E-03
CXY(141)=0.	CYX(141)=0.	CZX(141)= .999900E+31
CXY(142)=0.	CYX(142)=0.	CZX(142)=0.
CXY(143)=0.	CYX(143)=0.	CZX(143)= .999900E+31
CXY(144)=0.	CYX(144)=0.	CZX(144)=0.
CXY(145)= .529534E-03	CYX(145)= .249042E-03	CZX(145)= .129977E-02
CXY(155)=0.	CYX(155)=0.	CZX(155)= .999900E+31
CXY(156)=0.	CYX(156)=0.	CZX(156)=0.
CXY(157)= .325559E-04	CYX(157)= .238119E-03	CZX(157)= .325559E-04
CXY(158)= .319779E-03	CYX(158)= .213909E-03	CZX(158)= .234507E-02
CXY(169)=0.	CYX(169)=0.	CZX(169)= .999900E+31
CXY(170)=0.	CYX(170)=0.	CZX(170)=0.
CXY(171)= .150227E-03	CYX(171)= .161392E-03	CZX(171)= .737357E-02
CXY(183)= .162779E-04	CYX(183)= .595297E-04	CZX(183)=0.
CXY(184)= .253143E-03	CYX(184)= .144516E-03	CZX(184)= .632463E-03
CXY(253)= .999900E+31	CYX(253)=0.	CZX(253)= .999900E+31
CXY(254)= .464281E-05	CYX(254)=0.	CZX(254)=0.
CXY(255)= .139284E-04	CYX(255)= .810120E-04	CZX(255)= .185713E-04
CXY(256)= .999900E+31	CYX(256)=0.	CZX(256)=0.
CXY(257)= .162779E-04	CYX(257)= .176589E-03	CZX(257)= .325559E-04
CXY(258)=0.	CYX(258)= .122738E-03	CZX(258)= .821178E-03
CXY(267)=0.	CYX(267)=0.	CZX(267)= .999900E+31

CXY(268)=0.	CYX(268)=0.	CZX(268)=0.
CXY(269)=0.	CYX(269)=0.	CZX(269)= .999900E+31
CXY(270)=0.	CYX(270)=0.	CZX(270)=0.
CXY(271)= .529534E-03	CYX(271)= .249042E-03	CZX(271)= .129977E-02
CXY(281)=0.	CYX(281)=0.	CZX(281)= .999900E+31
CXY(282)=0.	CYX(282)=0.	CZX(282)=0.
CXY(283)= .325559E-04	CYX(283)= .238119E-03	CZX(283)= .325559E-04
CXY(284)= .319779E-03	CYX(284)= .213909E-03	CZX(284)= .234507E-02
CXY(295)=0.	CYX(295)=0.	CZX(295)= .999900E+31
CXY(296)=0.	CYX(296)=0.	CZX(296)=0.
CXY(297)= .150227E-03	CYX(297)= .161392E-03	CZX(297)= .737357E-02
CXY(309)= .162779E-04	CYX(309)= .595297E-04	CZX(309)=0.
CXY(310)= .253143E-03	CYX(310)= .144516E-03	CZX(310)= .632463E-03

CYX(379)=0.	CYX(380)=0.	CYX(381)= .816120E-04	CYX(382)=0.
CYX(383)= .178589E-03	CYX(384)= .122738E-03	CYX(	
CYX(393)=0.	CYX(394)=0.	CYX(395)=0.	CYX(396)=0.
CYX(397)= .249042E-03	CYX(		
CYX(407)=0.	CYX(408)=0.	CYX(409)= .238119E-03	CYX(410)= .213909E-03
CYX(421)=0.	CYX(422)=0.	CYX(423)= .161392E-03	CYX(435)= .595297E-04
CYX(436)= .144516E-03	CYY(		

THE THERMAL CONDUCTIVITY OF AIR IN THE CAVITY IS TKAIR IN W/M DEGREE C=0.02659

THE EMISSIVITIES USED ARE

E(1)=0.0400	E(2)=0.9000	E(3)=0.9000	E(4)=0.9000	E(5)=0.9000	E(6)=0.0400

THE RADIUS OF THE HOLES DRILLED IN THE PERSPEX IN METRES IS .177500E-01

F(1,1)=0.0000	F(1,2)=0.0990	F(1,3)=0.1687	F(1,4)=0.1352	F(1,5)=0.0569	F(1,6)=0.5401
F(2,1)=0.4746	F(2,2)=0.0508	F(2,3)=0.0921	F(2,4)=0.0766	F(2,5)=0.0328	F(2,6)=0.2730
F(3,1)=0.4045	F(3,2)=0.0461	F(3,3)=0.0989	F(3,4)=0.0882	F(3,5)=0.0383	F(3,6)=0.3241
F(4,1)=0.3241	F(4,2)=0.0383	F(4,3)=0.0882	F(4,4)=0.0989	F(4,5)=0.0461	F(4,6)=0.4045
F(5,1)=0.2730	F(5,2)=0.0328	F(5,3)=0.0766	F(5,4)=0.0921	F(5,5)=0.0508	F(5,6)=0.4746
F(6,1)=0.5401	F(6,2)=0.0569	F(6,3)=0.1352	F(6,4)=0.1687	F(6,5)=0.0990	F(6,6)=0.0000

THE AREAS ASSOCIATED WITH RADIATION AT THE POINTS INSIDE THE CYLINDER IN SQUARE METRES ARE

AA(1,2)= .322556E-05	AA(2,2)= .645113E-05	AA(3,2)= .645113E-05	AA(4,2)= .645113E-05	AA(5,2)= .322556E-05
AA(1,3)= .645113E-05	AA(2,3)= .129023E-04	AA(3,3)= .129023E-04	AA(4,3)= .129023E-04	AA(5,3)= .645113E-05
AA(1,4)= .645113E-05	AA(2,4)= .129023E-04	AA(3,4)= .129023E-04	AA(4,4)= .129023E-04	AA(5,4)= .645113E-05
AA(1,5)= .322556E-05	AA(2,5)= .645113E-05	AA(3,5)= .645113E-05	AA(4,5)= .645113E-05	AA(5,5)= .322556E-05

AR(1)=0.0009898	AR(2)=0.0002064	AR(3)=0.0004129	AR(4)=0.0004129	AR(5)=0.0002064	AR(6)=0.0009898

APPENDIX I

LISTING OF THE CAVITY PROBLEM SIMULATION PROGRAM

```
      B6700/B7700   F O R T R A N   C O M P I L A T I O N   M A R K   2.8.001
$ SET MERGE $

      DIMENSION CXY(504),CXZ(504),CYX(504),CYZ(504),CZY(504),CZX(504)
      DIMENSION T(504),RES(504)
      DIMENSION TT(504)
      DIMENSION E(6),F(6,6),TR(6),CAIR(5,5),QRADTJ(6)
      DIMENSION QRAD(5,5),QQ(6),AR(6),DQDT(5,5),RGELG(6),AA(5,5)
      DIMENSION QXY(504),QXZ(504),QYX(504),QYZ(504),QZY(504),QZX(504)
      EQUIVALENCE(CXY(1),CXZ(1)),(CYX(1),CYZ(1)),(CZX(1),CZY(1))
      EQUIVALENCE(QXY(1),QXZ(1)),(QYX(1),QYZ(1)),(QZX(1),QZY(1))
      DIMENSION QAIR(5,5)
      DIMENSION CRAD(504)
C
C
C     THE APPLICATION OF THE RELAXATION METHOD TO THE SOLUTION
C     OF DIFFERENTIAL EQUATIONS IN THREE DIMENSIONS
C
C     BOUNDARY VALUE POTENTIAL PROBLEMS
C
C
C
C
      NPITER=1
C     NPITER=NUMBER OF PROGRAM ITERATIONS
C
C     NX=NUMBER OF POINTS IN X DIRECTION
C     NY=NUMBER OF POINTS IN Y DIRECTION
C     NZ=NUMBER OF POINTS IN Z DIRECTION
      READ(5,27)NX,NY,NZ
   27 FORMAT(3I4)
      WRITE(6,28)NX,NY,NZ
   28 FORMAT(//,11X,'NX=',I4,10X,'NY=',I4,10X,'NZ=',I4)
      NXYZ=NX*NY*NZ
      READ(5,179)E(1),TKAIR
  179 FORMAT(F5.3,F8.5)
      READ(5,101)R
C
C     EVALUATION OF CONDUCTANCES USING SUBROUTINE CONDUC
C
   29 FORMAT(///,'THE CONDUCTANCES IN WATTS PER DEGREE KELVIN ARE')
      CALL CONDUC(CXY,CXZ,CYX,CYZ,CZX,CZY,NX,NY,NZ,DELTAY,TKAIR,R,SECAR1
     1,SECAR2)
C
C     THE EMISSIVITIES OF THE SURFACES IN THE ENCLOSURE
C     ARE SET
C
C     THE EMISSIVITY OF THE 2 ALUMINIUM DISKS ARE
      E(6)=E(1)
C
C     THE EMISSIVITIES OF THE PERSPEX REGIONS IN THE CAVITY ARE
      DO 100 I=2,5,1
      E(I)=0.9
  100 CONTINUE
C
C     THE RADIUS OF THE HOLE IS READ IN
  101 FORMAT(E9.3)
      WRITE(6,102)(I,E(I),I=1,6)
  102 FORMAT(///,10X,'THE EMISSIVITIES USED ARE',//,(11X,6(5X,'E(',I2,')=
     1'F6.4)))
      WRITE(6,103)R
  103 FORMAT(/,10X,'THE RADIUS OF THE HOLES DRILLED IN THE PERSPEX IN ME
     2TRES IS',E13.6)
C
C     SHAPE FACTORS COMPUTATION USING SUBROUTINE SHAPE F
C     RADIATION AREAS ALSO EVALUATED
C
      CALL SHAPEF(F,R,DELTAY,AR)
C
C     NOW WORK OUT AREAS ASSOCIATED WITH RADIATION TO THE
C     PARTICULAR TEMPERATURE POINTS INSIDE THE CYLINDER
C     FOR EXAMPLE-AA(158)=AREA OF TEMP. POINT 158 WHERE
C     RADIATION IS FALLING ON IN SQUARE METRES
C
```

```
      AA(5,2)=0.19635*R/2.*DELTAY/2.
      AA(1,2)=AA(5,2)
      AA(1,5)=AA(5,2)
      AA(5,5)=AA(5,2)
C
C
      AA(1,3)=0.19635*R/2.*DELTAY
      AA(5,3)=AA(1,3)
      AA(1,4)=AA(1,3)
      AA(5,4)=AA(1,3)
C
C
      AA(2,2)=0.19635*R*DELTAY/2.
      AA(3,2)=AA(2,2)
      AA(4,2)=AA(2,2)
      AA(2,5)=AA(2,2)
      AA(3,5)=AA(2,2)
      AA(4,5)=AA(2,2)
C
C
      AA(2,3)=0.19635*R*DELTAY
      AA(3,3)=AA(2,3)
      AA(4,3)=AA(2,3)
      AA(2,4)=AA(2,3)
      AA(3,4)=AA(2,3)
      AA(4,4)=AA(2,3)
      WRITE(6,107)
  107 FORMAT(//,10X,'THE AREAS ASSOCIATED WITH RADIATION AT THE POINTS I
     3NSIDE THE CYLINDER IN SQUARE METRES ARE')
      DO 109 J=2,5
      WRITE(6,108)(I,J,AA(I,J),I=1,5)
  108 FORMAT(/,3X,5('AA(',I1,',',I1,')=',E12.6,5X))
  109 CONTINUE
      WRITE(6,165)(I,AR(I),I=1,6)
  165 FORMAT(/,3X,6('AR(',I1,')=',F9.7,4X))
C
C
      WRITE(6,43)
   43 FORMAT(///,11X,'THE GUESSED TEMPERATURES FOR THE POINTS ARE')
      READ(5,44)(T(I),I=1,NXYZ)
   44 FORMAT(7F8.4)
      WRITE(6,45)(I,T(I),I=1,NXYZ)
   45 FORMAT(///,(1X,7(2X,'T(',I3,')=',F6.3)))
C
C
C
C     RADIATION ANALYSIS STARTS HERE
  146 CONTINUE
C
C
C
C     WORK OUT RADIATION TEMPS FOR EACH RADIATION REGION
C     FROM THE TEMPS OF BOUNDARY OF CYLINDER
C     E.G. TR(1)=TEMP OF RADIATION REGION 1
C
      TR(1)=(T(6)+T(19)+T(32)+T(45)+T(58))/5.
      TR(3)=(T(132)+T(145)+T(158)+T(171)+T(184))/5.
      TR(4)=(T(258)+T(271)+T(284)+T(297)+T(310))/5.
      TR(6)=(T(384)+T(397)+T(410)+T(423)+T(436))/5.
      TR(2)=(0.75*TR(1))+(0.25*TR(3))
      TR(5)=(0.75*TR(6))+(0.25*TR(4))
      TR(1)=TR(1)+273.0
      TR(2)=TR(2)+273.0
      TR(3)=TR(3)+273.0
      TR(4)=TR(4)+273.0
      TR(5)=TR(5)+273.0
      TR(6)=TR(6)+273.0
      WRITE(6,106)(I,TR(I),I=1,6)
  106 FORMAT(/,10X,6('TR(',I1,')=',F8.4,5X))
C
C
C     RADIATION BETWEEN FINITE AREAS SOLUTION
C     TO FIND OUTGOING FLUX FROM THE 6 RADIATION REGIONS
C     THAT IS QO
C
C     SET UP RADIOSITY EQUATIONS OF THE FORM
C     SUM OF ALL J'S FOR EACH SURFACE K
C     (KRONECKER-(1-E(K))*F(K,J))QO(J)=E(K)*SIGMA*T**4
```

```
C
      CALL RADIOS(TR,E,F,QO,RGELG,IER)
C
C     THE MATRIX OF OUTGOING FLUXES QO HAS BEEN SOLVED
C     THE ANSWERS ARE IN ARRAY RGELG
C     QO IS IN WATTS PER SQUARE METRE
      DO 121 I=1,6
      QO(I)=RGELG(I)
  121 CONTINUE
      WRITE(6,122)IER
  122 FORMAT(/,10X,'THE RESULTING ERROR PARAMETER IN INVERTING THE FLUX
     5MATRIX IS IER=',I4)
      WRITE(6,123)(I,QO(I),I=1,6)
  123 FORMAT(/,3X,6('QO(',I1,')=',E12.5,3X))
C
C     NOW THAT QO(K) HAS BEEN COMPUTED, QRADTO(K) IS FOUND
C     QRADTO(K) CAN BE REGARDED AS EITHER THE ENERGY SUPPLIED TO
C     SURFACE K BY EXTERNAL MEANS OR THE NET RADIATIVE
C     LOSS FROM SURFACE K RESULTING FROM RADIATION IN THE
C     ENCLOSURE
C
      SIGMA=5.6697E-08
      DO 124 I=1,6
      QRADTO(I)=AR(I)*E(I)/(1.-E(I))*(SIGMA*(TR(I)**4)-QO(I))
      QRADTO(I)=-QRADTO(I)
  124 CONTINUE
      WRITE(6,125)(I,QRADTO(I),I=1,6)
  125 FORMAT(/,3X,6('QRADTO(',I1,')=',F9.6,2X))
C
C     CONSIDER FOR EXAMPLE K=3
C     QRADTO(K)=TOTAL RADIATION ON SURFACE 3
C     BUT SURFACE 3 CONSISTS OF TEMP. POINTS 132,145,158,171
C     AND 184. - THE RADIATION TO EACH OF THESE IS -
C     QRAD(1,3),QRAD(2,3),QRAD(3,3),QRAD(4,3),AND QRAD(5,3) RESPECTIVELY
C     .
C     HENCE QRAD(1,3)=QRADTO(3)*AA(1,3)/AR(3),AND IN GENERAL
C     QRAD(I,J)=QRADTO(J)*AA(I,J)/AR(J)
C     WITH I - AS THE NUMBER COUNTER
C     J - AS THE PLANE COUNTER
C
C     START WITH RADIATION REGION 2
C
      DO 110 J=2,5
      QRAR2=QRADTO(J)/AR(J)
      DO 111 I=1,5
      QRAD(I,J)=QRAR2*AA(I,J)
  111 CONTINUE
  110 CONTINUE
      DO 126 J=2,5
      WRITE(6,127)(I,J,QRAD(I,J),I=1,5)
  127 FORMAT(/,3X,5('QRAD(',I1,',',I1,')=',F11.7,4X))
  126 CONTINUE
      IF(NPITER.GT.4) GO TO 160
C
C     START EVALUATING DQ BY DT FOR EACH TEMP REGION
C     ASSUME DQ BY DT IS CONSTANT WITH TEMP. IN EACH REGION
C     HENCE CALCULATE IT ONLY ONCE
C
      CALL DQBYDT(DQDT,QO,QRAD,E,F,TR,RGELG,AA)
C
 160  CONTINUE
C
C     NOW PERFORM THE OVER-ALL HEAT BALANCE
C     ACHIEVED USING SUBROUTINE RADREL
C     THAT IS RADIATION RELAXATION
C
C
      CALL RELAX(CXY,CYX,CZX,T,RES,NX,NY,NZ,CRAD,DQDT,QRAD,TR)
C     THE RADIATION RESIDUAL ITERATION HAS BEEN PERFORMED.
C     REPEAT THE WHOLE PROGRAM UNTIL NO FURTHER
C     SIGNIFICANT CHANGES OCCUR IN THE TEMPS. OF THE
C     INSIDE OF THE CYLINDER.  THAT IS, GO BACK TO STMT
C     WITH '146-CONTINUE'
      WRITE(6,148)NPITER
  148 FORMAT(/,10X,'THE NUMBER OF TOTAL PROGRAM ITERATIONS=',I3)
      IF(NPITER.EQ.10)GO TO 147
      NPITER=NPITER+1
      GO TO 146
  147 CONTINUE
C     EVALUATING THE HEAT FLOW BETWEEN POINTS USING  HEATFL
C
      WRITE(6,406)
 406  FORMAT(1H1)
      WRITE(6,51)
   51 FORMAT(///,11X,'THE HEAT FLUX PROFILE IS')
      CALL HEATFL(CXY,CYX,CZX,T,QXY,QYX,QZX,NX,NY,NZ,QAIR,CAIR,TR,AR,DEL
     1TAY,TKAIR,QRAD,SECAR1,SECAR2,QRADTO)
      CONTINUE
      STOP
      END
```

```
      SUBROUTINE CONDUC(CXY,CXZ,CYX,CYZ,CZX,CZY,NX,NY,NZ,DELTAY,TKAIR,R,
     1SECAR1,SECAR2)
      DIMENSION CXY(1),CXZ(1),CYX(1),CYZ(1),CZX(1),CZY(1)
      DIMENSION CAIR(5,5)
C
C     CONDUC EVALUATES THE CONDUCTANCES BETWEEN ANY POINTS.
C
C     NOTES ON NOMENCLATURE
C     CXY=CONDUCTANCE IN X DIRECTION WHEN CONSIDERING THE XY PLANE
C     CXZ=CONDUCTANCE IN X DIRECTION WHEN CONSIDERING THE XZ PLANE
C     HENCE CXY(I)=H*A/D=H*(DELTAY*DELTAZ)/DELTAX
C     SIMILAR DEFINITIONS APPLY FOR CYX,CYZ,CZX AND CZY
C
C     TKP=THERMAL CONDUCTIVITY OF PERSPEX
C     THICKNESS OF PERSPEX DIVIDED BY 3=DELTAY IN METRES
C     READING IN TKP AND DELTAY
      READ(5,10)TKP,DELTAY
   10 FORMAT(F9.7,E9.3)
      WRITE(6,52)TKP,DELTAY
   52 FORMAT(/,10X,'THE THERMAL CONDUCTIVITY OF PERSPEX=',
     1F6.4,'IN WATTS PER METRE PER DEGREE C',/,10X,
     2'THE THICKNESS OF PERSPEX DIVIDED BY 3 IN METRES=',E9.3)
C     COMPUTING CONDUCTANCES THAT ARE NEITHER B.C.S.
C     OR THOSE OF INFINITE CONDUCTANCE STARTS HERE.
C
C     CONDUCTANCES OF CXY AND CXZ
C
C     READ IN THE COEFFICIENT OF H,THAT IS,HC
C     READ IN THE COEFFICIENT OF AREA,THAT IS,AC
C     READ IN THE COEFFICIENT OF DISTANCE,THAT IS,DC
C
C     CXY(I)=CXZ(I)=(TKP*HC)*(DELTAY*AC)/DC
C
      WRITE(6,30)
   30 FORMAT(//,13X,'CONDUCTANCE',17X,'HC',20X,'AC',22X,'DC')
      DO 15 I=145,146,1
      READ(5,14)HC,AC,DC
   14 FORMAT(3F12.7)
      CXY(I)=(TKP*HC)*(DELTAY*AC)/DC
      CXY(I+126)=CXY(I)
      WRITE(6,56)I,CXY(I),HC,AC,DC,(I+126),CXY(I+126)
   56 FORMAT(/,1X,'CXY(',I3,')=',F12.6,3(10X,F12.6),10X,'CXY(',I3,')=',
     5F12.6)
   15 CONTINUE
      DO 16 I=158,161,1
      READ(5,14)HC,AC,DC
      CXY(I)=(TKP*HC)*(DELTAY*AC)/DC
      CXY(I+126)=CXY(I)
      WRITE(6,56)I,CXY(I),HC,AC,DC,(I+126),CXY(I+126)
   16 CONTINUE
      DO 17 I=171,176,1
      READ(5,14)HC,AC,DC
      CXY(I)=(TKP*HC)*(DELTAY*AC)/DC
      CXY(I+126)=CXY(I)
      WRITE(6,56)I,CXY(I),HC,AC,DC,(I+126),CXY(I+126)
   17 CONTINUE
      DO 18 I=184,191,1
      READ(5,14)HC,AC,DC
      CXY(I)=(TKP*HC)*(DELTAY*AC)/DC
      CXY(I+126)=CXY(I)
      WRITE(6,56)I,CXY(I),HC,AC,DC,(I+126),CXY(I+126)
   18 CONTINUE
      DO 19 I=198,206,1
      READ(5,14)HC,AC,DC
      CXY(I)=(TKP*HC)*(DELTAY*AC)/DC
      CXY(I+126)=CXY(I)
      WRITE(6,56)I,CXY(I),HC,AC,DC,(I+126),CXY(I+126)
   19 CONTINUE
      DO 20 I=212,221,1
      READ(5,14)HC,AC,DC
      CXY(I)=(TKP*HC)*(DELTAY*AC)/DC
      CXY(I+126)=CXY(I)
      WRITE(6,56)I,CXY(I),HC,AC,DC,(I+126),CXY(I+126)
   20 CONTINUE
      DO 21 I=226,236,1
```

```
      READ(5,14)HC,AC ,DC
      CXY(I)=(TKP*HC)*(DELTAY*AC)/DC
      CXY(I+126)=CXY(I)
      WRITE(6,56)I,CXY(I),HC,AC,DC,(I+126),CXY(I+126)
   21 CONTINUE
C     CONDUCTANCES OF CYX AND CYZ EVALUATED
C     USING SUBROUTINE CONYX
C
C     CYX(I)=CYZ(I)=TKP*(AC*1.E-06)/DELTAY
C
C     SINCE TKP AND DELTAY ARE FIXED AND READ IN ALREADY,
C     AC, THAT IS, THE AREA COEFFT IS THE ONLY VARIABLE
C
      WRITE(6,59)
   59 FORMAT(/,10X,'THE CONDUCTANCES OF CYX AND CYZ ARE')
      INITAL=132
      IFINAL=132
      CALL CONYX(CYX,CYZ,INITAL,IFINAL,TKP,DELTAY)
      INITAL=145
      IFINAL=147
      CALL CONYX(CYX,CYZ,INITAL,IFINAL,TKP,DELTAY)
      INITAL=158
      IFINAL=162
      CALL CONYX(CYX,CYZ,INITAL,IFINAL,TKP,DELTAY)
      INITAL=171
      IFINAL=177
      CALL CONYX(CYX,CYZ,INITAL,IFINAL,TKP,DELTAY)
      INITAL=184
      IFINAL=192
      CALL CONYX(CYX,CYZ,INITAL,IFINAL,TKP,DELTAY)
      INITAL=198
      IFINAL=207
      CALL CONYX(CYX,CYZ,INITAL,IFINAL,TKP,DELTAY)
      INITAL=212
      IFINAL=222
      CALL CONYX(CYX,CYZ,INITAL,IFINAL,TKP,DELTAY)
      INITAL=226
      IFINAL=237
      CALL CONYX(CYX,CYZ,INITAL,IFINAL,TKP,DELTAY)
C
C     CONDUCTANCES OF CZX AND CZY
C     EVALUATED USING SUBROUTINE COCZX
C
C     CZX(I)=CZY(I)=(TKP*HC)*(DELTAY*AC)/DC
C
      WRITE(6,405)
      WRITE(6,30)
  405 FORMAT(1H1)
      INITAL=132
      IFINAL=132
      CALL COCZX(CZX,CZY,INITAL,IFINAL,TKP,DELTAY)
      INITAL=145
      IFINAL=147
      CALL COCZX(CZX,CZY,INITAL,IFINAL,TKP,DELTAY)
      INITAL=158
      IFINAL=162
      CALL COCZX(CZX,CZY,INITAL,IFINAL,TKP,DELTAY)
      INITAL=171
      IFINAL=177
      CALL COCZX(CZX,CZY,INITAL,IFINAL,TKP,DELTAY)
      INITAL=184
      IFINAL=192
      CALL COCZX(CZX,CZY,INITAL,IFINAL,TKP,DELTAY)
      INITAL=198
      IFINAL=207
      CALL COCZX(CZX,CZY,INITAL,IFINAL,TKP,DELTAY)
      INITAL=212
      IFINAL=222
      CALL COCZX(CZX,CZY,INITAL,IFINAL,TKP,DELTAY)
C
C
C     AIR CONDUCTANCE EVALUATION STARTS HERE
C     INCLUDING CORRECTIONS OF SURFACE CONDUCTANCES IN Y DIRECTION
C
      R1=1.E-03
      R2=(R-R1)/4. +R1
      R3=(R-R1)/2. +R1
```

```
      R4=R3+ (R-R1)/4
      WRITE(6,192)R1,R2,R3,R4
  192 FORMAT(/,10X,'R1=',E12.5,6X,'R2=',E12.5,6X,'R3=',E12.5,6X,'R4=',E1
     12.5,4X,'IN METRES')
C
C     CONDUCTANCES FROM INNER AIR CORE TO OUTER AIR CYLINDER
C     THAT IS TOWARDS TEMP. 129
C
      PI=3.1415927
      AIRXC=TKAIR*2.*PI*DELTAY/(ALOG(R3/R1))
      CXY(128)=AIRXC/64.
      CXY(254)=CXY(128)
      CZX(129)=AIRXC/16.
      CZX(255)=CZX(129)
      CXY(129)=AIRXC*3./64.
      CXY(255)=CXY(129)
C
C     AIR CONDUCTANCES IN OUTER REGION TOWARDS SURFACE POINTS
C
      AIRXCO=TKAIR*2.*PI*DELTAY/(ALOG(R/R3))
      CXY(131)=AIRXCO/64.
      CXY(257)=CXY(131)
      CZX(131)=AIRXCO/32.
      CZX(257)=CZX(131)
      CXY(157)=CZX(131)
      CXY(283)=CZX(131)
      CZX(157)=CZX(131)
      CZX(283)=CZX(131)
      CXY(183)=CXY(131)
      CXY(309)=CXY(131)
C
C     AIR CONDUCTANCES EVALUATION IN Y-DIRECTION
C
C
      CYX(129)=TKAIR*PI*R2*R2/8./DELTAY
      CYX(255)=CYX(129)
      CYX(381)=CYX(129)
C
C     CONDUCTANCES IN Y DIRN ON RADIUS=R3, THAT IS THOSE
C     ASSOCIATED WITH POINTS 183,157 AND 131
C
      SEGARA=TKAIR*(R4-R2)*(R4+R2)*0.5/DELTAY
C     SEGARA=SECTOR AREA OF ANNULUS BTWN RADII R2 AND R4
      CYX(183)=SEGARA*11.25/2.*PI/180.
      CYX(157)=SEGARA*22.5*PI/180.
      CYX(131)=SEGARA*(11.25+(11.25/2.))*PI/180.
      CYX(309)=CYX(183)
      CYX(435)=CYX(183)
      CYX(283)=CYX(157)
      CYX(409)=CYX(157)
      CYX(257)=CYX(131)
      CYX(383)=CYX(131)
C
C     RE-EVALUATION OF SURFACE CONDUCTANCES IN Y DIRN
C     TAKING INTO ACCOUNT AIR CONDUCTANCE WHICH IS IN
C     PARALLEL TO SOLID CONDUCTANCE
C
      SECARA=TKAIR*(R-R4)*(R+R4)*0.5/DELTAY
C     SECARA=SECTOR AREA OF ANNULUS BTWN R4 AND SURFACE POINT
      SECAR1=SECARA*11.25/2.*PI/180.
      SECAR2=SECAR1*2
      CYX(184)=CYX(184)+SECAR1
      CYX(171)=CYX(171)+SECAR2
      CYX(158)=CYX(158)+SECAR2
      CYX(145)=CYX(145)+SECAR2
      CYX(132)=CYX(132)+SECAR1
      DO 188 I=132,184,13
      CYX(I+126)=CYX(I)
      CYX(I+252)=CYX(I)
  188 CONTINUE
C
C     SETTING UP INFINITE CONDUCTANCES CONNECTING
C     AIR TEMPS. TO INNER CORE AIR TEMP. THAT IS T(129)
C
      CI=9.999E+30
      DO 189 I=127,169,14
      CZX(I)=CI
```

```
      CZX(I+126)=CI
  189 CONTINUE
      CXY(127)=CI
      CXY(253)=CI
      CZX(143)=CI
      CZX(269)=CI
      CXY(130)=CI
      CXY(256)=CI
      WRITE(6,193)
  193 FORMAT(/,10X,'THE CONDUCTANCES OF POINTS ASSOCIATED WITH AIR IN TH
     1E CAVITY ARE')
      DO 195 I=127,132,1
      WRITE(6,194)I,CXY(I),I,CYX(I),I,CZX(I)
  194 FORMAT(/,10X,'CXY(',I3,')=',E12.6,6X,'CYX(',I3,')=',E12.6,6X,'CZX(
     1',I3,')=',E12.6)
  195 CONTINUE
      DO 196 I=141,145,1
      WRITE(6,194)I,CXY(I),I,CYX(I),I,CZX(I)
  196 CONTINUE
      DO 197 I=155,158,1
      WRITE(6,194)I,CXY(I),I,CYX(I),I,CZX(I)
  197 CONTINUE
      DO 198 I=169,171,1
      WRITE(6,194)I,CXY(I),I,CYX(I),I,CZX(I)
  198 CONTINUE
      DO 209 I=183,184
      WRITE(6,194)I,CXY(I),I,CYX(I),I,CZX(I)
209   CONTINUE
      DO 199 I=253,258,1
      WRITE(6,194)I,CXY(I),I,CYX(I),I,CZX(I)
  199 CONTINUE
      DO 200 I=267,271,1
      WRITE(6,194)I,CXY(I),I,CYX(I),I,CZX(I)
  200 CONTINUE
      DO 201 I=281,284,1
      WRITE(6,194)I,CXY(I),I,CYX(I),I,CZX(I)
  201 CONTINUE
      DO 202 I=295,297,1
      WRITE(6,194)I,CXY(I),I,CYX(I),I,CZX(I)
  202 CONTINUE
      DO 210 I=309,310
      WRITE(6,194)I,CXY(I),I,CYX(I),I,CZY(I)
210   CONTINUE
      WRITE(6,203)(I,CYX(I),I=379,384)
203   FORMAT(/,1X,4(10X,'CYX(',I3,')=',E12.6))
      WRITE(6,203)(I,CYX(I),I=393,397)
      WRITE(6,203)(I,CYX(I),I=407,410)
      WRITE(6,203)(I,CYX(I),I=421,423),(K,CYX(K),K=435,436)
      WRITE(6,150)TKAIR
  150 FORMAT(/,10X,'THE THERMAL CONDUCTIVITY OF AIR IN THE CAVITY IS TKA
     8IR IN W/M DEGREE C=',F7.5)
      RETURN
      END
```

```
      SUBROUTINE CONYX(CYX,CYZ,INITAL,IFINAL,TKP,DELTAY)
      DIMENSION CYX(1),CYZ(1)
C
C     CONYX-COMPUTES THE CONDUCTANCES CYX AND CYZ
C     USING THE READ-IN AREAS ONLY, AS THE THERMAL CONDUCTIVITY
C     AND THICKNESS OF PERSPEX ARE ALREADY READ IN.
C
      DO 23 I=INITAL,IFINAL,1
      READ(5,24)AC
   24 FORMAT(F12.7)
      CYX(I)=TKP*(AC*1.E-06)/DELTAY
      CYX(I+126)=CYX(I)
      CYX(I+252)=CYX(I)
      WRITE(6,58)I,CYX(I),(I+126),CYX(I+126),(I+252),CYX(I+252),AC
   58 FORMAT(/,10X,3('CYX(',I3,')=',F12.6,10X),'AC=',F10.6)
   23 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE COCZX(CZX,CZY,INITAL,IFINAL,TKP,DELTAY)
      DIMENSION CZX(1),CZY(1)
C
C     COCZX-COMPUTES THE CONDUCTANCES OF CZX AND CZY
C     USING THE FORMULA
C     CZX(I)=CZY(I)=(TKP*HC)*(DELTAY*AC)/DC
C
      DO 25 I=INITAL,IFINAL,1
      READ(5,26)HC,AC,DC
   26 FORMAT(3F12.7)
      CZX(I)=(TKP*HC)*(DELTAY*AC)/DC
      CZX(I+126)=CZX(I)
      WRITE(6,60)I,CZX(I),HC,AC,DC,(I+126),CZX(I+126)
   60 FORMAT(/,1X,'CZX(',I3,')=',F12.6,3(10X,F12.6),10X,'CZX(',I3,')=',
     1F12.6)
   25 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE RELAX(CXY,CYX,CZX,T,RES,NX,NY,NZ,CRAD,DQDT,QRAD,TR)
      DIMENSION CXY(1),CYX(1),CZX(1),T(1),RES(1)
      DIMENSION TT(504)
      DIMENSION CRAD(504),DQDT(5,5),QRAD(5,5)
      DIMENSION TR(6)
C
C     RELAX-EVALUATES THE TEMPERATURES BY RELAXATION
C
C
C     SETTING THE RADIATION CONDUCTANCE VALUES FOR SURFACE POINTS
C
      CXY(132)=-DQDT(1,3)
      CXY(144)=-DQDT(2,3)
      CZX(144)=-DQDT(3,3)
      CXY(170)=-DQDT(4,3)
      CZX(170)=-DQDT(5,3)
      CXY(258)=-DQDT(1,4)
      CXY(270)=-DQDT(2,4)
      CZX(270)=-DQDT(3,4)
      CXY(296)=-DQDT(4,4)
      CZX(296)=-DQDT(5,4)
      DO 205 I=132,258,126
      WRITE(6,204)I,CXY(I),(I+12),CXY(I+12),(I+12),CZX(I+12),(I+38),CXY(
     1I+38),(I+38),CZX(I+38)
  204 FORMAT(/,3X,2('CXY(',I3,')=',E12.5,4X),'CZX(',I3,')=',E12.5,4X,'CX
     2Y(',I3,')=',E12.5,4X,'CZX(',I3,')=',E12.5)
  205 CONTINUE
C
C     SETTING THE VALUES OF CRAD(I)
C     CRAD(I)=CONSTANT VALUE IN RELAXATION EQUATION
C     CRAD(I)=0 FOR INTERIOR NODAL POINTS
C     CRAD(I)=QRAD(I,J)FOR SURFACE POINTS
C
      I=1
      J=3
      DO 206 IJ=132,184,13
      CRAD(IJ)=QRAD(I,J)
      CRAD(IJ+126)=QRAD(I,J+1)
      I=I+1
  206 CONTINUE
      WRITE(6,207)(I,CRAD(I),I=132,184,13),(I,CRAD(I),I=258,310,13)
  207 FORMAT(/,3X,5('CRAD(',I3,')=',F11.7,4X))
      W=1.26
C     W-IS THE OVERRELAXATION FACTOR
      KI=1
C     KI-IS THE RESIDUALS ITERATIONS COUNTER
      LL=1
      L=1
C     LL AND L ARE THE WRITE UP COUNTERS
      TOL=0.00001
C     K IS THE TEMPERATURE COUNTER
   40 NR=1
      TOLM=0.00001
      J=3
      K=(NX*NZ)+1
   33 CONTINUE
      MR=(NX*NZ)+(NX*(NZ-1))
   31 CONTINUE
      IF(K.GT.MR)GO TO 32
      IF(K.EQ.133.OR.K.EQ.144) GO TO 212
      IF(K.EQ.259.OR.K.EQ.270) GO TO 212
      IF(K.EQ.170.OR.K.EQ.296) GO TO 212
      K1=K-1
      K2=K+1
      KNX1=K-NX
      KNX2=K+NX
      KNXZ1=K-(NX*NZ)
      KNXZ2=K+(NX*NZ)
      IF(K.EQ.132.OR.K.EQ.258) T(K2)=T(K)
      IF(K.EQ.145.OR.K.EQ.271) T(K1)=T(K)
      IF(K.EQ.158.OR.K.EQ.284) T(KNX1)=T(K)
      IF(K.EQ.171.OR.K.EQ.297) T(K1)=T(K)
      IF(K.EQ.184.OR.K.EQ.310) T(KNX1)=T(K)
      DEN=(CXY(K1)*T(K1))+(CXY(K)*T(K+1))+(CYX(KNXZ2)*T(KNXZ2))+CRAD(K)
      DEN=DEN+(CYX(K)*T(KNXZ1))+(CZX(KNX1)*T(KNX1))+(CZX(K)*T(KNX2))
      DENOMI=CXY(K1)+CXY(K)+CYX(KNXZ2)+CYX(K)+CZX(KNX1)+CZX(K)
```

```
      IF(DENOMI.EQ.0.0) GO TO 208
      DENUM=DEN/DENOMI
      RES(K)=DENUM-T(K)
      T(K)=T(K)+(W*RES(K))
 212  CONTINUE
 208  CONTINUE
      K=K+1
      GO TO 31
   32 K=K+NX
      NR=NR+1
      MR=MR+(NX*NZ)
      NZ1=NZ-1
      IF(NR.EQ.3) GO TO 34
      J=J+1
      GO TO 31
   34 CONTINUE
C
C     THE FIRST ESTIMATE OF TEMPS HAS BEEN OBTAINED.
C     RESIDUALS ITERATING STARTS HERE
C
      WRITE(6,300)(RES(J),J=1,504)
  300 FORMAT(/,(1X,14(F7.3,2X)))
      NR=1
      K=(NX*NZ)+1
   39 MR=(NX*NZ)+(NX*(NZ-1))
   35 CONTINUE
      IF(K.GT.MR) GO TO 37
      IF(ABS(RES(K)).GT.ABS(TOLM)) GO TO 36
      K=K+1
      GO TO 35
   36 TOLM=RES(K)
      K=K+1
      GO TO 35
   37 K=K+NX
      NR=NR+1
      MR=MR+(NX*NZ)
      NZ1=NZ-1
      IF(NR.EQ.3) GO TO 64
      GO TO 35
   64 IF(ABS(TOLM).LE.TOL) GO TO 42
      IF(KI.GT.20) GO TO 42
      IF(KI.EQ.L) GO TO 41
      KI=KI+1
      GO TO 40
 41   CONTINUE
      WRITE(6,65)KI
   65 FORMAT(///,11X,'THE NUMBER OF RESIDAUL ITERATIONS FOR THE TEMPERAT
     1URE PROFILE SHOWN BELOW=',I3)
      NXYZ=NX*NY*NZ
C     SF=SCALING FACTOR FOR WRITING FORMAT
      SF=1000.
      DO 66 I=1,NXYZ
      TT(I)=T(I)*SF
  66  CONTINUE
      WRITE(6,67)(TT(I),I=1,NXYZ,1)
   67 FORMAT(///,(1X,14(I5,3X)))
      KI=KI+1
      LL=LL+1
      L=1*LL
      GO TO 40
   42 CONTINUE
      WRITE(6,74)TOLM,TOL
   74 FORMAT(/,10X,'TOLM=',F7.4,5X,'TOL=',F7.4)
      WRITE(6,65)KI
      NXYZ=NX*NY*NZ
      SF=1000.
      DO 68 I=1,NXYZ
      TT(I)=T(I)*SF
   68 CONTINUE
      WRITE(6,67)(TT(I),I=1,NXYZ,1)
      RETURN
      END
```

```
      SUBROUTINE HEATFL(CXY,CYX,CZX,T,QXY,QYX,QZX,NX,NY,NZ,QAIR,CAIR,TR,
     1AR,DELTAY,TKAIR,QRAD,SECAR1,SECAR2,QRADTO)
      DIMENSION CXY(1),CYX(1),CZX(1),T(1),QXY(1),QYX(1),QZX(1)
      DIMENSION QAIR(5,5),CAIR(5,5),TR(6),AR(6)
      DIMENSION QRAD(5,5)
      DIMENSION QRADTO(6),SUMQXY(6),SUMQYX(6),SUMQZX(6)
      DIMENSION SQXYZ(6),QYXAIR(6),QXYAIR(6),QZXAIR(6),SQAIR(6)
C
C     HEATFL-COMPUTES THE HEAT FLUX BETWEEN POINTS
C
      NR=1
      KPLANE=1
C
C     ALTERING SUBROUTINE HEATFLOW
      K=(NX*NZ)+1
      CONTINUE
   71 MR=(NX*NZ)+(NX*(NZ-1))
   47 CONTINUE
      IF(K.GT.MR) GO TO 73
      K2=K+1
      KNX2=K+NX
      KNXZ1=K-(NX*NZ)
      QXY(K)=CXY(K)*(T(K)-T(K2))
      QYX(K)=CYX(K)*(T(K)-T(KNXZ1))
      QZX(K)=CZX(K)*(T(K)-T(KNX2))
      K=K+1
      GO TO 47
   73 CONTINUE
      K=K+NX
      NR=NR+1
      MR=MR+(NX*NZ)
      IF(NR.EQ.3) GO TO 49
      GO TO 47
   49 CONTINUE
      IF(K.GT.MR) GO TO 187
      KNXZ1=K-(NX*NZ)
      QYX(K)=CYX(K)*(T(K)-T(KNXZ1))
      K=K+1
      GO TO 49
C
 187  CONTINUE
      WRITE(6,213)
  213 FORMAT(/,10X,'THE HEAT BALANCE OF ALL INTERIOR POINTS IS')
      WRITE(6,185)
  185 FORMAT(1X,'PT NO',6X,'QYX(K)',7X,'QYX(K+126)',6X,'QXY(K-1)',10X,'Q
     1XY(K)',10X,'QZX(K-14)',8X,'QZX(K)',7X,'TOTAL HEAT FLOW',4X,'% ERRO
     2R')
      IHB=0
 186  CONTINUE
      INITAL=146+IHB
      IFINAL=147+IHB
      CALL HBPONT(QYX,QXY,QZX,TOTFLO,INITAL,IFINAL)
      INITAL=159+IHB
      IFINAL=162+IHB
      CALL HBPONT(QYX,QXY,QZX,TOTFLO,INITAL,IFINAL)
      INITAL=172+IHB
      IFINAL=177+IHB
      CALL HBPONT(QYX,QXY,QZX,TOTFLO,INITAL,IFINAL)
      INITAL=185+IHB
      IFINAL=192+IHB
      CALL HBPONT(QYX,QXY,QZX,TOTFLO,INITAL,IFINAL)
      INITAL=198+IHB
      IFINAL=207+IHB
      CALL HBPONT(QYX,QXY,QZX,TOTFLO,INITAL,IFINAL)
      INITAL=212+IHB
      IFINAL=222+IHB
      CALL HBPONT(QYX,QXY,QZX,TOTFLO,INITAL,IFINAL)
      INITAL=226+IHB
      IFINAL=237+IHB
      CALL HBPONT(QYX,QXY,QZX,TOTFLO,INITAL,IFINAL)
      IF(IHB.GT.1) GO TO 250
      IHB=IHB+126
      GO TO 186
 250  CONTINUE
```

```
C
C     HEAT BALANCE FOR SURFACE POINTS
C
      J=3
      I=1
      DO 215 IJ=132,258,126
      HEATIN=QXY(IJ-1)+QRAD(I,J)+QYX(IJ+126)
      HITUUT=QZX(IJ)+QYX(IJ)
      TOTFLO=HEATIN-HITOUT
      PECERR=TOTFLO/((ABS(HEATIN+HITOUT))/2.)*100.
      WRITE(6,216)(IJ-1),QXY(IJ-1),I,J,QRAD(I,J),(IJ+126),QYX(IJ+126),HE
     1ATIN
  216 FORMAT(/,5X,'QXY(',I3,')=',E11.4,7X,'QRAD(',I1,',',I1,')=',E11.4,7
     2X,'QYX(',I3,')=',E11.4,7X,'HEATIN=',E11.4)
      WRITE(6,217)IJ,QZX(IJ),IJ,QYX(IJ),HITOUT,TOTFLO,PECERR
  217 FORMAT(/,5X,'QZX(',I3,')=',E11.4,6X,'QYX(',I3,')=',E11.4,6X,'HEATO
     1UT=',E11.4,6X,'TOTFLO=',E11.4,6X,'HEAT BALANCE ERROR %=',F6.3)
      J=J+1
  215 CONTINUE
C
C     HEAT BALANCE FOR POINT 145
C
      I=2
      J=3
      DO 218 IJ=145,271,126
      HEATIN=QZX(IJ-14)+QYX(IJ+126)+ORAD(I,J)
      HITUUT=QYX(IJ)+QXY(IJ)+QZX(IJ)
      TOTFLO=HEATIN-HITOUT
      PECERR=TOTFLO/((ABS(HEATIN+HITOUT))/2.)*100.
      WRITE(6,219)(IJ-14),QZX(IJ-14),I,J,GRAD(I,J),(IJ+126),QYX(IJ+126),
     1HEATIN
  219 FORMAT(/,5X,'QZX(',I3,')=',E11.4,7X,'QRAD(',I1,',',I1,')=',E11.4,7
     1X,'QYX(',I3,')=',E11.4,7X,'HEATIN=',E11.4)
      WRITE(6,220)IJ,QYX(IJ),QXY(IJ),QZX(IJ),HITOUT,TOTFLU,PECERR
  220 FORMAT(/,1X,'PT NO',I3,'QYX=',E11.4,5X,'QXY=',E11.4,5X,'QZX=',E11.
     14,5X,'HEATOUT=',E11.4,6X,'TOTFLO=',E11.4,6X,'%ERROR=',F6.3)
      J=J+1
  218 CONTINUE
C
C     HEAT BALANCE FOR POINT 158
C
      I=3
      J=3
      DO 221 IJ=158,284,126
      HEATIN=QXY(IJ-1)+QRAD(I,J)+QYX(IJ+126)
      HITUUT=QYX(IJ)+QXY(IJ)+QZX(IJ)
      TOTFLO=HEATIN-HITOUT
      PECERR=TOTFLO/((ABS(HEATIN+HITOUT))/2.)*100.
      WRITE(6,216)(IJ-1),QXY(IJ-1),I,J,QRAD(I,J),(IJ+126),QYX(IJ+126),HE
     1ATIN
      WRITE(6,220)IJ,QYX(IJ),QXY(IJ),QZX(IJ),HITOUT,TOTFLU,PECERR
      J=J+1
  221 CONTINUE
C
C     HEAT BALANCE FOR POINT 171
C
      I=4
      J=3
      DO 222 IJ=171,297,126
      HEATIN=QZX(IJ-14)+ORAD(I,J)+QYX(IJ+126)
      HITUUT=QYX(IJ)+QXY(IJ)+QZX(IJ)
      TOTFLO=HEATIN-HITOUT
      PECERR=TOTFLO/((ABS(HEATIN+HITDUT))/2.)*100.
      WRITE(6,219)(IJ-14),QZX(IJ-14),I,J,GRAD(I,J),(IJ+126),QYX(IJ+126),
     1HEATIN
      WRITE(6,220)IJ,QYX(IJ),QXY(IJ),QZX(IJ),HITOUT,TOTFLU,PECERR
      J=J+1
  222 CONTINUE
C
C     HEAT BALANCE FOR POINT 184
C
      I=5
      J=3
      DO 223 IJ=184,310,126
      HEATIN=QXY(IJ-1)+QRAD(I,J)+QYX(IJ+126)
      HITUUT=QYX(IJ)+QXY(IJ)+QZX(IJ)
      TOTFLO=HEATIN-HITOUT
```

```
      PECERR=TOTFLO/((ABS(HEATIN+HITOUT))/2.)*100.
      WRITE(6,216)(IJ-1),QXY(IJ-1),I,J,QRAD(I,J),(IJ+126),QYX(IJ+126),HE
     1ATIN
      WRITE(6,220)IJ,QYX(IJ),QXY(IJ),QZX(IJ),HITOUT,TOTFLO,PECERR
      J=J+1
  223 CONTINUE
C
C     HEAT BALANCE FOR NODAL POINTS ASSOCIATED WITH AIR
C
C     CONSIDER POINT 129
C
      DO 224 IJ=129,255,126
      HEATIN=QXY(IJ-1)+QYX(IJ+126)
      HITOUT=QYX(IJ)+QXY(IJ)+QZX(IJ)
      TOTFLO=HEATIN-HITOUT
      PECERR=TOTFLO/((ABS(HEATIN+HITOUT))/2.)*100.
      WRITE(6,225)(IJ-1),QXY(IJ-1),(IJ+126),QYX(IJ+126),HEATIN
  225 FORMAT(/,5X,'QXY(',I3,')=',E11.4,7X,'QYX(',I3,')=',E11.4,7X,'HEATI
     1N=',E11.4)
      WRITE(6,220)IJ,QYX(IJ),QXY(IJ),QZX(IJ),HITOUT,TOTFLO,PECERR
  224 CONTINUE
C
C     SUMMING THE SOLID CONDUCTION HEAT FLOWS
C     THE HEAT FLOWS NEXT TO SURFACE ARE RE-EVALUATED
C     SO THAT AIR CONDUCTION IS SEPARATED
C
      DO 230 I=1,6
      SUMQXY(I)=0.0
      SUMQYX(I)=0.0
      SUMQZX(I)=0.0
  230 CONTINUE
      J=3
      ISUM=0
C     ISUM IS USED FOR REGION COUNTING
C     START WITH QXY
C
      SUMQXY(3)=QXY(145)+QXY(146)
      SUMQXY(4)=QXY(271)+QXY(272)
  231 CONTINUE
      INITAL=158+ISUM
      IFINAL=161+ISUM
      DO 171 I=INITAL,IFINAL
      SUMQXY(J)=SUMQXY(J)+QXY(I)
  171 CONTINUE
      INITAL=171+ISUM
      IFINAL=176+ISUM
      DO 172 I=INITAL,IFINAL
      SUMQXY(J)=SUMQXY(J)+QXY(I)
  172 CONTINUE
      INITAL=184+ISUM
      IFINAL=191+ISUM
      DO 173 I=INITAL,IFINAL
      SUMQXY(J)=SUMQXY(J)+QXY(I)+QXY(I+NX)+QXY(I+(2*NX))+QXY(I+(3*NX))
  173 CONTINUE
      I=206+ISUM
      SUMQXY(J)=SUMQXY(J)+QXY(I)+QXY(I+14)+QXY(I+15)+QXY(I+28)
      SUMQXY(J)=SUMQXY(J)+QXY(I+29)+QXY(I+30)
      IF(ISUM.GT.1) GO TO 232
      ISUM=ISUM+126
      J=J+1
      GO TO 231
  232 CONTINUE
C
C     QAIR(I,J)-DEFINE THIS AS THE AIR HEAT FLOW
C     IN Y-DIRECTION ASSOCIATED WITH SURFACE POINTS
C
      I=1
      J=3
      DO 233 IJ=132,384,126
      QAIR(I,J)=SECAR1*(T(IJ)-T(IJ-126))
      QAIR(I+4,J)=SECAR1*(T(IJ+52)-T(IJ-74))
      QAIR(I+1,J)=SECAR2*(T(IJ+13)-T(IJ-113))
      QAIR(I+2,J)=SECAR2*(T(IJ+26)-T(IJ-100))
      QAIR(I+3,J)=SECAR2*(T(IJ+39)-T(IJ-87))
      J=J+1
  233 CONTINUE
C
```

```
C      SUBTRACTING AIR CONDUCTION FROM(SOLID+AIR)CONDUCTION
C      IN Y-DIRECTION
C
       I=1
       J=3
       DO 234 IJ=132,184,13
       QYX(IJ)=QYX(IJ)-QAIR(I,J)
       QYX(IJ+126)=QYX(IJ+126)-QAIR(I,J+1)
       QYX(IJ+252)=QYX(IJ+252)-QAIR(I,J+2)
       I=I+1
   234 CONTINUE
C
C      CONSIDERING QYX AND QZX
C
       J=3
       ISUM=0
       SUMQYX(3)=SUMQYX(3)+QYX(132)+QYX(145)+QYX(146)+QYX(147)
       SUMQYX(4)=SUMQYX(4)+QYX(258)+QYX(271)+QYX(272)+QYX(273)
       SUMQYX(5)=SUMQYX(5)+QYX(384)+QYX(397)+QYX(398)+QYX(399)
       SUMQZX(3)=SUMQZX(3)+QZX(132)+QZX(145)+QZX(146)+QZX(147)
       SUMQZX(4)=SUMQZX(4)+QZX(258)+QZX(271)+QZX(272)+QZX(273)
   235 CONTINUE
       INITAL=158+ISUM
       IFINAL=162+ISUM
       DO 174 I=INITAL,IFINAL
       SUMQYX(J)=SUMQYX(J)+QYX(I)
       SUMQZX(J)=SUMQZX(J)+QZX(I)
   174 CONTINUE
       INITAL=171+ISUM
       IFINAL=177+ISUM
       DO 175 I=INITAL,IFINAL
       SUMQYX(J)=SUMQYX(J)+QYX(I)
       SUMQZX(J)=SUMQZX(J)+QZY(I)
   175 CONTINUE
       INITAL=184+ISUM
       IFINAL=192+ISUM
       DO 176 I=INITAL,IFINAL
       SUMQYX(J)=SUMQYX(J)+QYX(I)+QYX(I+NX)+QYX(I+(2*NX))
       SUMQZX(J)=SUMQZX(J)+QZX(I)+QZX(I+NX)+QZX(I+(2*NX))
   176 CONTINUE
       I=207+ISUM
       SUMQYX(J)=SUMQYX(J)+QYX(I)+QYX(I+14)+QYX(I+15)
       SUMQZX(J)=SUMQZX(J)+QZX(I)+QZX(I+14)+QZX(I+15)
       INITAL=226+ISUM
       IFINAL=237+ISUM
       DO 177 I=INITAL,IFINAL
       SUMQYX(J)=SUMQYX(J)+QYX(I)
   177 CONTINUE
       IF(ISUM.GE.252) GO TO 236
       ISUM=ISUM+126
       J=J+1
       GO TO 235
   236 CONTINUE
C
C
C      PUTTING Y-DIRECTION SURFACE HEAT FLOWS TO WHAT THEY
C      WERE BEFORE
C
       I=1
       J=3
       DO 237 IJ=132,184,13
       QYX(IJ)=QYX(IJ)+QAIR(I,J)
       QYX(IJ+126)=QYX(IJ+126)+QAIR(I,J+1)
       QYX(IJ+252)=QYX(IJ+252)+QAIR(I,J+2)
       I=I+1
   237 CONTINUE
C
C      WRITING THE HEAT FLOW IN SOLID CONDUCTION
C
       DO 240 I=3,5
       SQXYZ(I)=ABS(SUMQYX(I))+ABS(SUMQXY(I))+ABS(SUMQZX(I))
   240 CONTINUE
       TOSUCO=SQXYZ(3)+SQXYZ(4)+SQXYZ(5)
C      TOSUCO IS THE TOTAL SOLID CONDUCTION
       WRITE(6,238)
   238 FORMAT(/,10X,'REGION  NUMBER',10X,'SUM OF QYX',14X,'SUM OF QXY',13
      1X,'SUM OF QZX',11X,'SUM OF QY,QX AND QZ')
```

```
      WRITE(6,239)(I,SUMQYX(I),SUMQXY(I),SUMQZX(I),SQXYZ(I),I=3,5)
  239 FORMAT(/,14X,I4,15X,E13.6,10X,E13.6,10X,E13.6,10X,E13.6)
      WRITE(6,241)TOSUCO
  241 FORMAT(/,20X,'TOTAL HEAT CONDUCTED IN SOLID=TOSUCO=',E13.6)
C
C     COMPUTING AIR CONDUCTION
C
      DO 244 I=1,6
      QYXAIR(I)=0.0
      QXYAIR(I)=0.0
      QZXAIR(I)=0.0
      SQAIR(I)=0.0
  244 CONTINUE
C
C     QYXAIR(I)=SUM OF AIR CONDUCTION IN Y DIRECTION
C     QXYAIR(I)=SUM OF AIR CONDUCTION IN X DIRECTION
C     QZXAIR(I)=SUM OF AIR CONDUCTION IN Z DIRECTION
C
      DO 242 J=3,5
      DO 242 I=1,5
      QYXAIR(J)=QYXAIR(J)+QAIR(I,J)
  242 CONTINUE
      J=3
      DO 243 I=129,381,126
      QYXAIR(J)=QYXAIR(J)+QYX(I)+QYX(I+2)+QYX(I+26)+QYX(I+54)
      QXYAIR(J)=QXYAIR(J)+QXY(I)+QXY(I+2)+QXY(I+26)+QXY(I+54)
      QZXAIR(J)=QZXAIR(J)+QZX(I)+QZX(I+2)+QZX(I+26)+QZX(I+54)
      J=J+1
  243 CONTINUE
      DO 245 J=3,5
      SQAIR(J)=ABS(QYXAIR(J))+ABS(QXYAIR(J))+ABS(QZXAIR(J))
  245 CONTINUE
      TOAIRC=SQAIR(3)+SQAIR(4)+SQAIR(5)
C     TOAIRC=IS THE TOTAL HEAT CONDUCTED BY AIR
      WRITE(6,246)
  246 FORMAT(/,10X,'REGION  NUMBER',10X,'QYXAIR(J)',15X,'QXYAIR(J)',14X,
     1'QZXAIR(J)',10X,'SUM OF REGIONAL AIR CONDUCTION')
      WRITE(6,239)(I,QYXAIR(I),QXYAIR(I),QZXAIR(I),SQAIR(I),I=3,5)
      WRITE(6,247)TOAIRC
  247 FORMAT(/,20X,'TOTAL HEAT CONDUCTED BY AIR=',E13.6,'IN WATTS')
C
C     SUMMING RADIATION TRANSFERED
C
      TOTRAD=ABS((QRADTO(1)+QRADTO(2)+(QRADTO(3)/2.))/8.)
C     TOTRAD=IS THE TOTAL HEAT TRANSFERED BY RADIATION
      HEATR=SQXYZ(3)+SQAIR(3)+TOTRAD
      WRITE(6,248)SQXYZ(3),SQAIR(3),TOTRAD,HEATR
  248 FORMAT(//,1X,'SOLIDCO=',E13.6,10X,'AIRCO=',E13.6,10X,'TOTRAD=',E13
     1.6,10X,'HEAT TRANSFERED=',E13.6)
      HTAIR=SQAIR(3)*16.*8.
      HTRAD=TOTRAD*16.*8.
      HTSOLI=SQXYZ(3)*16.*8.
      CONRAD=HTAIR+HTRAD+HTSOLI
      WRITE(6,249)HTSOLI,HTAIR,HTRAD,CONRAD
  249 FORMAT(/,20X,'HEAT TRANSFERED BY THE THREE MODES FOR THE WHOLE PLA
     1TE IN THE EXPERIMENT IS',//,1X,'SOLID CONDUCTION=',E13.6,5X,'AIR C
     2ONDUCTION=',E13.6,5X,'RADIATION=',E13.6,5X,'TOTAL HEAT TRANSFERED=
     3',E13.6)
      RETURN
      END
```

```
      SUBROUTINE SHAPEF(F,R,DELTAY,AR)
      DIMENSION F(6,6),AR(6)
      FDITRI(H,R)=1./2.*(H/R*(SQRT(4.+(H*H/(R*R))))-(H*H/(R*R)))
      FRITRI(H1,H2,R)=(H2/2./R)+(1./4.*((SQRT(4.+(H1*H1)/(R*R)))+((H2/H1
     1)*(SQRT(4.+(H2*H2)/(R*R))))-((H1+H2)/H1*(SQRT(4.+((H1+H2)*(H1+H2)/
     2(R*R)))))))
C
C     SHAPEF-COMPUTES THE SHAPE FACTORS FOR THE CYLINDRICAL HOLE
C
C     FOR A CYLINDER DIVIDED INTO 4 RADIATION REGIONS
C     THE SHAPE FACTORS ARE
C     1-FROM ONE RING TO ANOTHER RING-E.G. F(2,3),F(3,4),F(4,5)
C     2-FROM ANY RING TO A DISK-E.G.F(2,1),F(3,1),F(5,6),F(4,6)
C     3-FROM A DISK TO ANOTHER DISK-E.G.F(1,6)
C
C     FDITRI-SHAPE FACTOR EQN FOR SOLVING DISK TO RING FACTORS
C     FRITRI-SHAPE FACTOR EQN FOR SOLVING RING TO RING FACTORS
C     THE HOLE THRU THE PERSPEX IS DIVIDED INTO 4 RING REGIONS
C     THAT IS,2,3,4, AND 5
C     THE TWO END DISK REGIONS ARE 1 AND 6
C
C
C     THE RADIATION SURFACE AREAS IN SQUARE METRES ARE -
      PI=3.1416
      AR(1)=PI*R*R
      AR(6)=AR(1)
C     THE ABOVE ARE THE DISK AREAS
C     THE RING AREAS ARE
      AR(2)=PI*R*DELTAY
      AR(5)=AR(2)
      AR(3)=2.*PI*R*DELTAY
      AR(4)=AR(3)
C
C     SHAPE FACTOR EVALUATION STARTS HERE
C
C     SHAPE FACTORS OF DISK TO DISK
      H=DELTAY*3.
      F(1,6)=1.-FDITRI(H,R)
      F(6,1)=F(1,6)
C
C     SHAPE FACTORS OF DISK TO RING
C
C     COMPUTING F(1,2)
      H=DELTAY/2.
      F(1,2)=FDITRI(H,R)
      F(6,5)=F(1,2)
C     COMPUTING F(1,3)
      H=DELTAY+(DELTAY/2.)
      F123=FDITRI(H,R)
      F(1,3)=F123-F(1,2)
      F(6,4)=F(1,3)
C     COMPUTING F(1,4)
      H=DELTAY+DELTAY+(DELTAY/2.)
      F1234=FDITRI(H,R)
      F(1,4)=F1234-F(1,2)-F(1,3)
      F(6,3)=F(1,4)
C     COMPUTING F(1,5)
      H=3.*DELTAY
      F12345=FDITRI(H,R)
      F(1,5)=F12345-F(1,2)-F(1,3)-F(1,4)
      F(6,2)=F(1,5)
C     COMPUTING F(1,1)
      F(1,1)=1.-(F12345+F(1,6))
      F(6,6)=F(1,1)
C
C     SHAPE FACTORS FOR RING TO RING
C
C     COMPUTING F(2,3)
      H1=DELTAY/2.
      H2=DELTAY
      F(2,3)=FRITRI(H1,H2,R)
      F(5,4)=F(2,3)
C     COMPUTING F(2,4)
      H1=DELTAY/2.
      H2=DELTAY+DELTAY
      F234=FRITRI(H1,H2,R)
```

```
      F(2,4)=F234-F(2,3)
      F(5,3)=F(2,4)
C     COMPUTING F(2,5)
      H1=DELTAY/2.
      H2=DELTAY+DELTAY+(DELTAY/2.)
      F2345=FRITRI(H1,H2,R)
      F(2,5)=F2345-F(2,3)-F(2,4)
      F(5,2)=F(2,5)
C     COMPUTING F(3,4)
      H1=DELTAY
      H2=DELTAY
      F(3,4)=FRITRI(H1,H2,R)
      F(4,3)=F(3,4)
C
C     ALL THE SHAPE FACTORS THAT ARE NECESSARY TO FIND
C     ALL THE OTHER SHAPE FACTORS HAVE NOW BEEN EVALUATED
C     NOW USING CONFIGURATION-FACTOR ALGEBRA, FIND THE OTHER
C     SHAPE FACTORS.
C
C     STARTING WITH SHAPE FACTORS F(2,J)
      F(2,1)=AR(1)*F(1,2)/AR(2)
      F(2,6)=AR(6)*F(6,2)/AR(2)
      F(2,2)=1.-(F(2,1)+F(2,3)+F(2,4)+F(2,5)+F(2,6))
C
C     CONSIDERING SHAPE FACTORS F(3,J)
      F(3,1)=AR(1)*F(1,3)/AR(3)
      F(3,2)=AR(2)*F(2,3)/AR(3)
      F(3,5)=AR(5)*F(5,3)/AR(3)
      F(3,6)=AR(6)*F(6,3)/AR(3)
      F(3,3)=1.-(F(3,1)+F(3,2)+F(3,4)+F(3,5)+F(3,6))
C     CONSIDERING SHAPE FACTORS F(4,J)
      F(4,1)=AR(1)*F(1,4)/AR(4)
      F(4,2)=AR(2)*F(2,4)/AR(4)
      F(4,5)=F(3,2)
      F(4,6)=F(3,1)
      F(4,4)=1.-(F(4,1)+F(4,2)+F(4,3)+F(4,5)+F(4,6))
C     CONSIDERING SHAPE FACTORS F(5,J)
      F(5,1)=F(2,6)
      F(5,6)=AR(6)*F(6,5)/AR(5)
      F(5,5)=1.-(F(5,1)+F(5,2)+F(5,3)+F(5,4)+F(5,6))
      DO 104 I=1,6
      WRITE(6,105)(I,J,F(I,J),J=1,6)
  105 FORMAT(/,10X,6('F(',I1,',',I1,')=',F6.4,5X))
  104 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE RADIOS(TR,E,F,QO,R,IER)
      DIMENSION TR(6),E(6),F(6,6),QO(6),R(6),A(6,6)
C
C     RADIOS-EVALUATES THE RADIOSITIES QO BY MATRIX INVERSION
C
C     SET UP MATRIX OF COEFFICIENTS A(M,M)
C     R.H.S. OF MATRIX IS R(M,N)
C     BOTH OF THESE MATRICES ARE DESTROYED ON INVERSION
C     SOLN STORED IN R-AFTER USING SUBROUTINE GELG
C
      A(1,1)=1.-((1.-E(1))*F(1,1))
      DO 112 I=2,6
      A(I,1)=-((1.-E(I))*F(I,1))
  112 CONTINUE
      A(1,2)=-((1.-E(1))*F(1,2))
      A(2,2)=1.-((1.-E(2))*F(2,2))
      DO 113 I=3,6
      A(I,2)=-((1.-E(I))*F(I,2))
  113 CONTINUE
      DO 114 I=1,2
      A(I,3)=-((1.-E(I))*F(I,3))
  114 CONTINUE
      A(3,3)=1.-((1.-E(3))*F(3,3))
      DO 115 I=4,6
      A(I,3)=-((1.-E(I))*F(I,3))
  115 CONTINUE
      DO 116 I=1,3
      A(I,4)=-((1.-E(I))*F(I,4))
  116 CONTINUE
      A(4,4)=1.-((1.-E(4))*F(4,4))
      DO 117 I=5,6
      A(I,4)=-((1.-E(I))*F(I,4))
  117 CONTINUE
      DO 118 I=1,4
      A(I,5)=-((1.-E(I))*F(I,5))
  118 CONTINUE
      A(5,5)=(1.-((1.-E(5))*F(5,5)))
      A(6,5)=-((1.-E(6))*F(6,5))
      DO 119 I=1,5
      A(I,6)=-((1.-E(I))*F(I,6))
  119 CONTINUE
      A(6,6)=1.-((1.-E(6))*F(6,6))
      WRITE(6,161)
  161 FORMAT(/,10X,'THE MATRIX OF COEFFTS OF RADIOSITY EQNS USED IS')
      DO 162 J=1,6
      WRITE(6,163)(I,J,A(I,J),I=1,6)
  163 FORMAT(/,4X,6('A(',I1,',',I1,')=',F11.7,3X))
  162 CONTINUE
C
C     R IS THE M*N MATRIX OF RIGHT HAND SIDES
C     COMPUTED BELOW
      SIGMA=5.6697E-08
      DO 120 I=1,6
      R(I)=E(I)*SIGMA*(TR(I)**4)
  120 CONTINUE
      WRITE(6,164)(I,R(I),I=1,6)
  164 FORMAT(/,10X,'R.H.S. OF RADIOSITY EQUATIONS ARE ',/,5X,6('R(',I1,'
     8)=',E13.6,3X))
C
C     THE REST OF THE ARGUMENTS IN GELG ARE SET BELOW
C
      M=6
      N=1
      EPS=1.E-08
      CALL GELG(R,A,M,N,EPS,IER)
C
C     THE SYSTEM OF QO EQNS HAS BEEN SOLVED
C     THE ANSWERS ARE IN R
C
      RETURN
      END
```

```
      SUBROUTINE DQBYDT(DQDT,QD,QRAD,E,F,TR,RGELG,AA)
      DIMENSION DQDT(5,5),QD(6),QRAD(5,5),E(6),F(6,6),TR(6)
      DIMENSION RGELG(6),AA(5,5)
      SIGMA=5.6697E-08
      DELTAT=0.3
C
C     START WITH RADIATION REGION 2
C     J=RADIATION REEGION COUNTER
C     I=TEMP COUNTER FOR A GIVEN RADIATION REGION
C
      DO 129 J=2,5
      TR(J)=TR(J)+DELTAT
      SIGT4=4.*(TR(J)**3)/((TR(J)**4)-((TR(J)-DELTAT)**4))
      CALL RADIOS(TR,E,F,QD,RGELG,IER)
C     VALUE OF OUTGOING RADIATIVE FLUX IS IN RGELG(J)
      QRDQTJ=E(J)/(1.-E(J))*(SIGMA*(TR(J)**4)-RGELG(J))
      QRDQTJ=-QRDQTJ
C     QRDQTJ=QRADTO(J) TO BE USED IN DQ/DV CALCN PER UNIT AREA
      DO 128 I=1,5
      QRAD12=QRDQTJ*AA(I,J)
      DQDT(I,J)=(QRAD12-QRAD(I,J))*SIGT4
  128 CONTINUE
      TR(J)=TR(J)-DELTAT
  129 CONTINUE
      DO 131 J=2,5
      WRITE(6,130)(I,J,DQDT(I,J),I=1,5)
  130 FORMAT(/,3X,5('DQDT(',I1,',',I1,')=',F11.6,4X))
  131 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE GELG(R,A,M,N,EPS,IER)
      DIMENSION A(1),R(1)
C
C     ..................................................................
C
C        SUBROUTINE GELG
C
C        PURPOSE
C           TO SOLVE A GENERAL SYSTEM OF SIMULTANEOUS LINEAR EQUATIONS.
C
C        USAGE
C           CALL GELG(R,A,M,N,EPS,IER)
C
C        DESCRIPTION OF PARAMETERS
C           R      - THE M BY N MATRIX OF RIGHT HAND SIDES.  (DESTROYED)
C                    ON RETURN R CONTAINS THE SOLUTION OF THE EQUATIONS.
C           A      - THE M BY M COEFFICIENT MATRIX.  (DESTROYED)
C           M      - THE NUMBER OF EQUATIONS IN THE SYSTEM.
C           N      - THE NUMBER OF RIGHT HAND SIDE VECTORS.
C           EPS    - AN INPUT CONSTANT WHICH IS USED AS RELATIVE
C                    TOLERANCE FOR TEST ON LOSS OF SIGNIFICANCE.
C           IER    - RESULTING ERROR PARAMETER CODED AS FOLLOWS
C                    IER=0  - NO ERROR,
C                    IER=-1 - NO RESULT BECAUSE OF M LESS THAN 1 OR
C                             PIVOT ELEMENT AT ANY ELIMINATION STEP
C                             EQUAL TO 0,
C                    IER=K  - WARNING DUE TO POSSIBLE LOSS OF SIGNIFI-
C                             CANCE INDICATED AT ELIMINATION STEP K+1,
C                             WHERE PIVOT ELEMENT WAS LESS THAN OR
C                             EQUAL TO THE INTERNAL TOLERANCE EPS TIMES
C                             ABSOLUTELY GREATEST ELEMENT OF MATRIX A.
C
C        REMARKS
C           INPUT MATRICES R AND A ARE ASSUMED TO BE STORED COLUMNWISE
C           IN M*N RESP. M*M SUCCESSIVE STORAGE LOCATIONS. ON RETURN
C           SOLUTION MATRIX R IS STORED COLUMNWISE TOO.
C           THE PROCEDURE GIVES RESULTS IF THE NUMBER OF EQUATIONS M IS
C           GREATER THAN 0 AND PIVOT ELEMENTS AT ALL ELIMINATION STEPS
C           ARE DIFFERENT FROM 0. HOWEVER WARNING IER=K - IF GIVEN -
C           INDICATES POSSIBLE LOSS OF SIGNIFICANCE. IN CASE OF A WELL
C           SCALED MATRIX A AND APPROPRIATE TOLERANCE EPS, IER=K MAY BE
C           INTERPRETED THAT MATRIX A HAS THE RANK K. NO WARNING IS
C           GIVEN IN CASE M=1.
C
C        SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
C           NONE
C
C        METHOD
C           SOLUTION IS DONE BY MEANS OF GAUSS-ELIMINATION WITH
C           COMPLETE PIVOTING.
C
C     ..................................................................
C
C
      IF(M)23,23,1
C
C     SEARCH FOR GREATEST ELEMENT IN MATRIX A
    1 IER=0
      PIV=0.
      MM=M*M
      NM=N*M
      DO 3 L=1,MM
      TB=ABS(A(L))
      IF(TB-PIV)3,3,2
    2 PIV=TB
      I=L
    3 CONTINUE
      TOL=EPS*PIV
C     A(I) IS PIVOT ELEMENT. PIV CONTAINS THE ABSOLUTE VALUE OF A(I).
C
C
C     START ELIMINATION LOOP
      LST=1
      DO 17 K=1,M
C
```

```
C        TEST ON SINGULARITY
      IF(PIV)23,23,4
    4 IF(IER)7,5,7
    5 IF(PIV-TOL)6,6,7
    6 IER=K-1
    7 PIVI=1./A(I)
      J=(I-1)/M
      I=I-J*M-K
      J=J+1-K
C        I+K IS ROW-INDEX, J+K COLUMN-INDEX OF PIVOT ELEMENT
C
C        PIVOT ROW REDUCTION AND ROW INTERCHANGE IN RIGHT HAND SIDE R
      DO 8 L=K,NM,M
      LL=L+I
      TB=PIVI*R(LL)
      R(LL)=R(L)
    8 R(L)=TB
C
C        IS ELIMINATION TERMINATED
      IF(K-M)9,18,18
C
C        COLUMN INTERCHANGE IN MATRIX A
    9 LEND=LST+M-K
      IF(J)12,12,10
   10 II=J*M
      DO 11 L=LST,LEND
      TB=A(L)
      LL=L+II
      A(L)=A(LL)
   11 A(LL)=TB
C
C        ROW INTERCHANGE AND PIVOT ROW REDUCTION IN MATRIX A
   12 DO 13 L=LST,MM,M
      LL=L+I
      TB=PIVI*A(LL)
      A(LL)=A(L)
   13 A(L)=TB
C
C        SAVE COLUMN INTERCHANGE INFORMATION
      A(LST)=J
C
C        ELEMENT REDUCTION AND NEXT PIVOT SEARCH
      PIV=0.
      LST=LST+1
      J=0
      DO 16 II=LST,LEND
      PIVI=-A(II)
      IST=II+M
      J=J+1
      DO 15 L=IST,MM,M
      LL=L-J
      A(L)=A(L)+PIVI*A(LL)
      TB=ABS(A(L))
      IF(TB-PIV)15,15,14
   14 PIV=TB
      I=L
   15 CONTINUE
      DO 16 L=K,NM,M
      LL=L+J
   16 R(LL)=R(LL)+PIVI*R(L)
   17 LST=LST+M
C        END OF ELIMINATION LOOP
C
C
C        BACK SUBSTITUTION AND BACK INTERCHANGE
   18 IF(M-1)23,22,19
   19 IST=MM+M
      LST=M+1
      DO 21 I=2,M
      II=LST-I
      IST=IST-LST
      L=IST-M
      L=A(L)+.5
      DO 21 J=II,NM,M
      TB=R(J)
      LL=J
      DO 20 K=IST,MM,M
      LL=LL+1
   20 TB=TB-A(K)*R(LL)
      K=J+L
      R(J)=R(K)
   21 R(K)=TB
   22 RETURN
C
C
C        ERROR RETURN
   23 IER=-1
      RETURN
      END
```

```
      SUBROUTINE HBPONT(QYX,QXY,QZX,TOTFLO,INITAL,IFINAL)
      DIMENSION QYX(504),QXY(504),QZX(504)
C
C     HBPONT-EVALUATES THE HEAT BALANCE BETWEEN INTERIOR
C     NODAL POINTS
C
      DO 184 K=INITAL,IFINAL
      HEATIN=QYX(K+126)+QXY(K-1)+QZX(K-14)
      HITOUT=QYX(K)+QXY(K)+QZX(K)
      TOTFLO=-QYX(K)+QYX(K+126)+QXY(K-1)-QXY(K)+QZX(K-14)-QZX(K)
      PECERR=TOTFLO/((ABS(HEATIN + HITOUT))/2.)*100.
      WRITE(6,183)K,QYX(K),QYX(K+126),QXY(K-1),QXY(K),QZX(K-14),QZX(K),T
     4OTFLO,PECERR
  183 FORMAT(///,1X,I4,3X,7(E11.4,6X,),F6.3)
      WRITE(6,214)HEATIN,HITOUT
  214 FORMAT(10X,'HEAT INTO POINT=',E13.6,10X,'HEAT CONDUCTED AWAY FROM
     1POINT=',E13.6)
  184 CONTINUE
      RETURN
      END
```